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Cover: Turtles of Turkey. Upper left: *Trionyx triunguis*. Dalyan, 6/16/00. Upper right: *Testudo graeca anamurensis*. Anamurium, Anamur, 6/11/00. Lower left: *Mauvemyx caspica rivulata* Mamure Kalesi, Anamur, 6/10/00. *Emys orbicularis*. Lower right: Mamure Kalesi, Anamur, 6/10/00. All photographs by Tonya Van Leuvan-Smith.

The Reproductive Biology of *Rana Boulengeri*

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Abstract.- Maturation of *Rana Boulengeri* Günther occurs at the age of 24 to 36 months. After reproduction the gonads are in an intermittent period. Gonads begin to develop rapidly from next February to April. After May, the ovocytes grow mature in batches. In the wild, the adult frogs often spawn under waterfalls or in shallow pools where the water flows slowly, with high dissolved oxygen. The reproductive period lasts from May to August. The ovulation time of females and fertilization time are generally from 5:00 a.m. to 8:00 a.m. The Water temperature for deposition at the beginning is 15.5°C and the appropriate temperature for most deposition is 17.7-22.5°C. The total duration under artificial constant temperature of 23±0.5°C lasts 261 hours. The appropriate temperature for development is 22-24°C. This species can not develop below 4°C, and it dies at 30°C. The development of the ovary is divided into 6 stages and the development of the testis is divided into 5 stages. The morphological and histological studies at different stages of sex cells are described.

Key words.- Amphibia, *Rana Boulengeri*, reproductive biology, China

Introduction

Rana Boulengeri is a large frog that is found in the Wuling Mountains of Hunan Province. It is an important species for maintaining the ecological balance of the region (Yuan and Wen, 1990). Besides, it can be used as a kind of medicine (Li et al., 1993). In order to help protect this natural resource, these studies on its reproductive biology have been carried out.

Material and Methods

Laboratory experiment and artificial breeding

The studies on the natural condition of habitat, growth and ages, characteristics of reproduction, the development of genital gland and development of the embryo of *Rana Boulengeri* was conducted for four years from 1989 to 1993.

Field investigation

The field sites chosen for investigation were places where *Rana Boulengeri* are common. Field observations were made two or three times a month.

Results and Discussion

Habitat

Natural habitat of *Rana Boulengeri*. The Xiang Xi mountains are a part of the Wuling Mountains, which are located on the border of Hunan, Hubei, Sichuan and Guizhou; between north Latitude 27°44'- 29°48' and east longitude 109°10'-111°20'; with a mean elevation of 686 meters (the highest, 1900 meters above

sea level; the lowest, 75 meters above sea level). The mountains are covered with evergreen broad-leaf sub-tropical forest. The mean air temperatures for a whole year are 16.10 degree-days. The temperature summation above 10°C is 50320; the mean sun hours per year are 1292.7h; frostless period is 270.6 days; the mean rainfall per year is 1397.2mm; the mean humidity per year is above 82% (R.H). These conditions constitute an ideal environment for *Rana Boulengeri*.

Rana Boulengeri frequently live in brooks or ponds in mountain forests where there are few people. The water in the brooks or ponds is very clear. During the day, *R. Boulengeri* often hide at the edge of small caves and during the night, they go out to feed. From July to September of 1987, the physical factors in 35 observation points were measured. Their values are: the elevation of the habitat is 204-675 meters above sea level; air temperature 17.2-24°C; water temperature 14.9-20.5°C; the depth of water 0.2-1.0 meters; the transparency of water 0.2-1.0 m; the humidity 92.0-97.5%.

Activities of *Rana Boulengeri* and temperatures of habitat. Because the air temperature and water temperature play important roles in the development and growth of *R. Boulengeri*; we observed their relationship in a cave (450m above sea level). In autumn, when the water temperature fall lower than 12.5°C, *R. Boulengeri* begins hibernation. In spring, when water temperature is above 12.5°C, they start to feed, and when water temperature is higher than 15.5°C, they enter the reproductive period. The air temperatures and water temperatures in all months are listed in Table 1.

Table 1. Air and water temperatures of the habitat of *Rana Boulengeri* (450m above sea level).

Month	Mean air temperature	Mean water temperature
1	8.1	11.0
2	10.0	12.2
3	10.8	12.8
4	13.0	14.4
5	14.6	14.9
6	16.3	16.1
7	23.9	16.5
8	22.1	16.3
9	18.1	16.1
10	16.1	12.9
11	13.1	11.5
12	8.2	10.0

Chemical properties of the water.

The chemical characteristics of the water inhabited by *R. Boulengeri* were measured and analyzed. The results are listed in Table 2. On the whole, the water is clear, thin, neutral and acidulous, with some contents of Ca, Mg and other minerals.

Vertical distribution. *Rana Boulengeri* are distributed vertically from 200 to 700 meters above sea level, but most of them are found from 450 to 650 meters. Older, large adult frogs are mostly found above 600 meters, while young frogs and tadpoles are found lower.

Growth and age

When bred in artificial pools, the mean body length and the mean body weight of the frogs just completing metamorphosis are 19.8 mm and 0.95 g respectively.

When feeding lasts to the end of the year, their body weight increases to 3.07 g and their body length to 31.2 mm. After feeding for 2 years, their body weight grows to 20.50 g, and the body length to 58.1 mm. The growth curves of body weight and body length are logistic (i.e. "S" shaped) (Li, et al., 1993). In the field, it was found that the largest male was 261 g with a body length of 134 mm. The largest female was 202 g with body length of 120 mm.

Reproductive characteristics

Environmental conditions of breeding areas. In the wild, the adult frogs often spawn under waterfalls or in shallow pools. The mean water area and mean water depth of natural spawn areas are 2.16 m² and 0.35 m respectively. The water flows slowly with high dissolved oxygen. The mean value of pH is 6.3. Generally, there are small stones, sand, ratty plant and leaves, or humus on the bottom. There are bryophytes and algae on the bottom as well as on the sides of the pools.

Reproductive period. In west Hunan at 563 m above sea level, *R. Boulengeri* begin reproduction in May and end in August. The reproductive peak is in June and July. Female frogs may have three clutches, the egg number of the second and third clutches depend on the availability of food and environmental conditions.

Temperature. When water temperature reaches 15.5°C *R. Boulengeri* begins to spawn. The optimum temperatures for large numbers of females to spawn are 17.7-22.5°C. From July to August, the mean air temperature of natural spawning sites is 21.4°C, and the optimum humidity is above 95%.

Reproductive behavior. In middle or late March, *R. Boulengeri* end their hibernation and feed for a month. Then the male and female frogs aggregate at spawning fields. Before mating, male frogs call for about 15 days as a courting period. The ovulation time of females and fertilization times are generally from 5:00 a.m. to 8:00 a.m. When the female spawns, she creeps slowly and her cloaca is near the walls of pool or brooks.

Table 2. Analysis of the water inhabited by *R. Boulengeri* (mg/L). Date of analysis: 5, January, 1990; elevation where water was sampled: 204m above sea level.

pH	total hardness	Ca	Mg	Cu	Zn	Fe	Hg	Mn	Cd
6.71	12.92°C	58.36	13.66	0.013	0.183	0.793	0.001	0.036	0.003
Pb	Ag	Co	Cr	Do	Sulfate	N(NO ₂)	N(HNO ₃)	N(NH ₄)	Water type
0.0148	0.002	0.017	0.0199	4.45	9.89	0.001	0.026	0.075	Thin acidulous

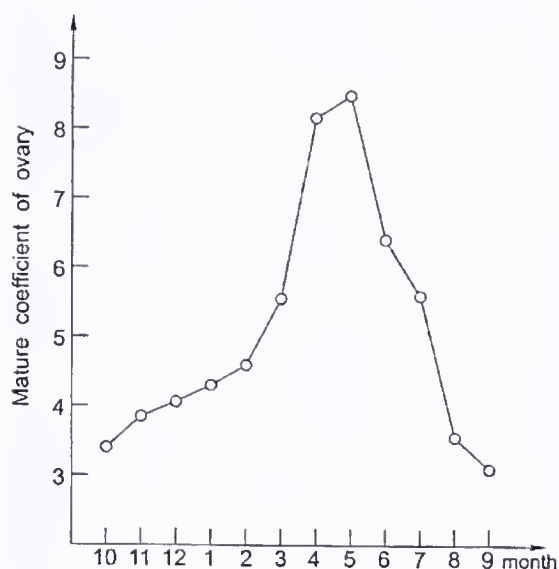


Figure 1. The seasonal change of Mature coefficient of ovary (1991-1993)

Eggs. The mean number of eggs spawned in each batch is about 218. The egg of *R. boulengeri* is big with a mean diameter of 3.98 mm, enveloped by 3 layers of gum membrane (The diameter of egg including membrane is 15.85 mm). The outer layer is the thickest, the inner layer the thinnest. The outer layer is very sticky, so that many eggs connect together to form a long cluster, the end of egg cluster is stuck on the wall or to ratty plants under water.

Development of genital glands

Development of ovary. The development of ovary can be divided into 6 stages.

Stage 1. Multiplication period of ovogonium: The body weights (BW) of young frogs are 7.3-12.5 g and the body lengths (BL) are 37.2-43.6 mm. The ovogonium cells, aggregating densely with the ability of division, have not been surrounded by follicle cells.

Stage 2. Growth of ovocyte (ovocyte): When the BW of young frog are 10.2-19.5 g and BL are 47.2-56.2 mm, ovogonium cells develop into ovocyte cells. The ovocyte clusters are divided by connective tissue of the ovary and surrounded by follicle cells.

Stage 3. Transition growth of ovocyte: When BW of young frog are 36.5-74.2 g and BL are 71.7-84.3 mm, the volume of ovocyte cells increases. The follicle cells increase from 1 to 2 layers and the zona pellucida becomes clear.

Early stage 4. Formation of yolk in ovocyte: When young frogs weigh 58.7-80.8 g and their BL are 81.5-89.7 mm, ovocytes begin rapid growth and particles of yolk begin to form.

Late stage 4. Ovocyte cells filled with yolk: When frogs have BW of 79.7-125.8 g and BL of 87.3-98.0 mm, the ovum cells are fully filled with yolk and the nuclei are isolated in the middle of the cells. The two layers of follicle cells and zona pellucida are well marked.

Stage 5. Slanting of nucleus of ovocyte: When BW are 86.3-161.5 g and BL are 89.4-112.3 mm, the nucleus inclines to the side of animal pole. At this stage, the female can ovulate under the action of gonadotrophic hormone.

Stage 6. Ovary after ovulation: When frogs body weights decrease to 70.6-102.5 g and body length decrease to 82.1-100.2 mm. In this stage, corpora lutea appear in ovary.

Development of testis. The development of testis can be divided into 5 stages.

Stage 1. Multiplication period of spermatogonium: At this stage, spermatogonium aggregates densely, and ranges irregularly.

Stage 2. Formation of sperm-tube: In this stage, the spermatogonium is separated into sperm-tube by connective tissue of testis and part of spermatogonium in sperm-tube becomes spermatocyte of the first order.

Stage 3. Differentiation of spermatocyte: In this stage, the number of spermatogonium in sperm-tube decreases. On the wall of sperm-tube, there are primary sperm mother cells, secondary sperm mother cells and spermatophore formed by spermatoblast respectively.

Stage 4. Formation of sperm: This is the ripe stage of the testis. The spermatogonium and the spermatocyte of the first order are few on the wall of sperm-tube instead of spermatocyte of the secondary order and spermatophore formed by spermatoblast respectively. After the forming of spermatozoon, the spermatozoon aggregates densely first, then disperses.

Stage 5. Post-ejecting: Most spermatozoons have been ejected and only a few could be found in the sperm-tube.

Female order of ovary development and age at sexual maturity. After metamorphosis, the ovaries of the young frogs reach stage 1 in 2-3 months; stage 2 in 6-8 months; stage 3 in 10-13 months; early stage 4 in 21-24 months; late stage 4 and stage 5 in 33-36 months (if ecological conditions are very suitable, in only 22-24 months), when the females can spawn naturally or artificially. After spawning, the ovaries reaches stage 6.

Male order of testis development and age at sexual

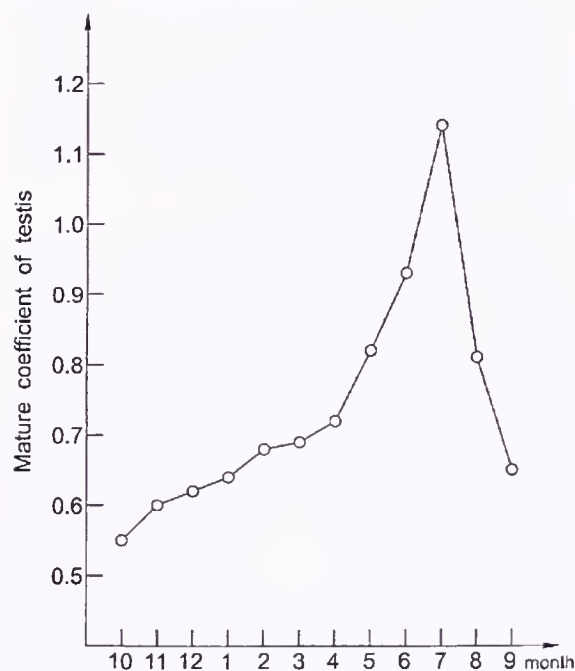


Figure 2. The seasonal change of Mature coefficient of testis (1991-1993)

maturity. After metamorphosis, the testes of males develop into stage 1 in 2-4 months; stage 2 in 8-10 months; stage 3 in 14-18 months; stage 4 in 24-26 months. At this stage the males can mate with the females.

Type of spawning. In the sexually mature females, 3-4 grades of oocyte can be seen. This is the cytological proof of multi-oviposition of *Rana boulengeri*.

Seasonal change of ovaries. The period from May to August is the reproductive time of *R. boulengeri*. Then the ovaries develop slowly and the mature coefficient of ovary (MCO) decreases to 3.10-3.35%. From February to April of the second year, the ovaries develop fast and the MCO reaches its highest value (5.73-14.5%). The mean value of MCO in May is 8.47% (Fig.1). After May, the ovocytes mature in batches.

Seasonal change of testes. The testes change little during the different seasons. The range of change of mature coefficient of testis (MCT) in a year is 0.55-1.14%. From April to July, testes develop faster than in other months. In July the MCT is 1.14%. In October the MCT decreases to 0.55% (Fig.2).

Embryonic development

Li et al. (1993) reported in detail on the embryonic development of *R. boulengeri*. Under temperature conditions of $23 \pm 0.5^\circ\text{C}$, 261.05 ± 0.54 hours were required for the embryo to complete its development.

The whole development procedure is divided into 25 stages on the basis of both the morphological and the physiological changes during this period (Pollister and Moore, 1937; Shumway, 1940). The temperature summation above 0°C for the embryo to complete the whole development is 6004.15 degree-hours.

Experiments have shown that temperature can affect the developmental rate of the embryo of *R. boulengeri*. Under conditions of 13°C , 16°C , 22°C , 24°C , 26°C and 28°C , the time for the embryo to complete development is 937.97h, 687.78h, 321.61h, 304.76h, 300.18h and 295.17h. In 2°C and 4°C water the embryo can not develop. In 7°C water the embryo develops very slowly. In 30°C water, the embryo can not complete development. The optimum temperatures for embryonic development are 22°C - 24°C (Li et al., 1994).

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A New Species of *Batrachuperus* from Northwestern China

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Abstract.— We describe a new species of salamander in the genus *Batrachuperus* from Tsinling Mts. in western China. The new species is morphologically most similar to *B. longdongensis*, but differentiated by the absence of horny covers on palms and tarsi. It represents the most northeastern distribution and the lowest elevation of the genus.

Key words.— Caudata, *Batrachuperus*, new species, China, Tsinling

Introduction

The salamander genus *Batrachuperus* Boulenger, 1878 contains seven species (Frost, 1985). Three species occur on the western side of the Tibet Plateau (Iran and Afghanistan). The remaining four species are found on the eastern side of the Tibet Plateau in China. During the fieldwork in 1986 and 1999, we collected specimens of *Batrachuperus* from Zhouzhi, China. This collection marks the most northeastern distribution of the genus. The specimens are different

from all other described species (Fei et al., 1990), and we describe them as a new species.

Batrachuperus taibaiensis, new species (Fig. 1). Taibai Stream Salamander

Holotype: NIEA 860122. An adult male from the upper stream of Heihe River, near Hua Er Ping Village, Zhouzhi County, Shaanxi Province, China (33.85°N, 107.82°E), collected by M. Song on August 8, 1986, elevation 1260m. The holotype is deposited



Figure 1. Paratype of *Batrachuperus taibaiensis* (MVZ 230964).

at the herpetological collection of Northwest Institute of Endangered Animals, Xi'an, China.

Paratypes: Allotype, NIEA 860116, an adult female, collected from the same locality at the same time as the holotype. Other paratypes include NIEA 860114-5, 860117-9, 860121, 860126-7, 860129-139 and MVZ 230964-65, 230979-86. The NIEA series are collected from the same locality at the same time as the holotype and are deposited at the herpetology collection of Northwest Institute of Endangered Animals, Xi'an, China. The MVZ series are collected from the same locality on September 30, 1999 by Z. Liu, and are deposited at the herpetology collection of the Museum of Vertebrate Zoology, University of California, Berkeley.

Diagnosis: A relatively large, robust stream salamander; distinguished from other members of the genus by the large size, vomerine teeth arranged in a "Λ" shape, and lack of horny cover on palms and tarsa. Morphologically, the species most closely resembles *B. longdongensis*. Both species are distinguished from others by large size and vomerine teeth arranged in a "Λ" shape. Between the two species, *B. longdongensis* differs from *B. taibaiensis* by the presence of the horny cover on palms, tarsa, and tail tip, as well as the presence of gill slits in adults. *Batrachupe-*

rus taibaiensis is distinguished from geographically neighboring species, *B. tibetanus*, by its large size and the arrangement of vomerine teeth. Most phylogenetically closely related to *B. karlschmidti* and *B. tibetanus*. Its cytochrome *b* gene sequence differs from *B. longdongensis* by 9.2%, from *B. karlschmidti* by 7%, and from *B. tibetanus* by 8.2-8.6% (J. Fu et al., unpublished data).

Description: *Batrachupeus taibaiensis* is a large (adults males over 217 mm maximum SL), stout species. Head moderately depressed, its length from snout to gular fold longer than its width; snout short and round. Labial fold well developed, often partially covers the lower jar. Angle of jaw just behind the posterior corner of eye. Both maxilla and mandible with tiny teeth. Tongue elliptical, without free end. Vomerine teeth four, arranged in "Λ" shape.

Body stout. Male body length slightly longer than tail length and female body and tail length about the same. Costal grooves 11. Limbs relatively short but strong; when adpressed, tips of digits do not overlap and are always separated by 1-3 costal folds in adults, but contacted in juveniles. Separation is greater in males. Fingers four, 3-2-4-1 in order of length. Toes four, 3-2-4-1 in order of length. Most individuals without palmar and tarsal tubercles. No horny cover

Table 1. Measurement (range, means) and percentage ratios of each character dimension to SVL. All measurements are in mm.

Measurement	Holotype	Allotype	Male (n=11)	Juvenile	Female (n=9)
Snout-vent length	102	105	92.9±12.1 73—110	65	102.1±7.1 94—111
Tail length	115	105	98.5±13.7 76—115	60	101.3±7.5 91—113
Head length	26	27	25.4±2.9 20—29	19	27.2±1.5 25—28
Head width	23	25	20.4±1.6 18—23	13	21.4±1.7 19—25
Forelimb length	26	22	22.7±2.5 20—27	18	23.7±1.2 22—26
Hindlimb length	30	30	29.6±3.0 25—36	21	30.9±2.5 23—34
Limb interval	52	51	44.8±7.9 33—59	30	52.2±8.7 44—68
Vomerine teeth	4	4	4	4	4

on palms, tarsi, and ventral side of the fingers, and toes. Some individuals have horny cover of the very tips of the fingers and toes. Tail round at the base and gradually flattened laterally. Tail fin moderately high. Skin smooth. The measurements of the type specimens are presented in table 1.

Habitat and distribution: This species is only known from the type locality, which is the most north-eastern distribution of the genus and the only known location from the northern slope the Tsinling Mts. It has also the lowest elevation of the genus (1260m).

This species inhabits in fast moving streams (close to the headwater of Heihe River). During daytime, they are found under rocks in the stream, and have never been observed under rocks on the riverbank. The stream is well covered by the canopy from both sides of the river and has steep slopes.

Etymology: The name *taibaiensis* is derived from the name of the nearby peak, Taibai Peak, which is the highest point of Tsinling Mts.

Remarks: Recent phylogenetic study of the genus supported the species status of *B. taibaiensis* (Fu et al. unpublished data). It is the sister group of the clade including *B. karlschmidti* and *B. tibetanus*. Together,

the clade is the sister group of *B. yenyuansis* and *B. pinchonii*.

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A New Snake of the Genus *Hologerrhum* Günther (Reptilia; Squamata; Colubridae) from Panay Island, Philippines

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Abstract.— We describe a new species of snake in the genus *Hologerrhum* from two forested localities in Antique Province, Panay Island, Philippines. To clarify species boundaries, we also redescribe its only known congener, *H. philippinum*, on the basis of historical collections and newly-acquired material from the Islands of Luzon, Marinduque, Polillo, and Catañduanes. The new species is the first *Hologerrhum* from the Visayan Aggregate Island Complex and differs from *Hologerrhum philippinum* in color pattern and scalation of head and body. The new species is one of several recently described vertebrates from Panay Island. Together, they indicate that forested regions of the individual islands of the Visayan Aggregate Island Complex (Negros, Panay, Cebu, Masbate, and other associated smaller islands) contain low levels of taxonomic endemism that warrant further study.

Key words.— Colubridae, *Hologerrhum*, Philippines, Panay Island, Visayas.

Introduction

Günther (1858) erected the monotypic genus *Hologerrhum* to accommodate a single specimen from Hugh Cuming's Philippine collections that had been deposited in the Natural History Museum, London (Günther, 1873; Fig. 1A). Günther distinguished the new genus and species from members of the Philippine genus *Cyclochorus* by the presence of slight grooves in the enlarged fang-like teeth at the posterior end of the maxilla. Other slight differences between *Hologerrhum* and some species of *Cyclochorus*, not emphasized by Günther but mentioned by other workers (Taylor, 1922a, 1922b; Leviton, 1965), include color pattern, slight scale pattern differences, and less strongly enlarged middle series of maxillary teeth in *Hologerrhum*.

At the time of the description of *Hologerrhum*, no specific (island) locality data were available, but Günther later (1879) referred a specimen from Placer, northeast Mindanao Island to this species. That specimen (not seen by us) apparently is a representative of the genus *Cyclochorus* Taylor 1922c (*vide* Boulenger, 1896; see also comment by Taylor, 1922a:116).

Jan and Sordelli (1870) described *Cyclochorus maculatus* (generic name misspelled), on the basis of

a specimen reportedly from Java Island, Indonesia (Fig. 1B). Fischer (1885) followed by recognizing *Cyclochorus lineatus* var. *maculatus* reportedly from S. Mindanao Island, Philippines, but without reference to new material. The type specimen of *Cyclochorus maculatus* later was shown to be a representative of *H. philippinum* (Günther, 1873, 1879; Boettger, 1886; Taylor, 1922a), suggesting locality errors by both Jan and Sordelli and Fisher. Later, Leviton (1965) inadvertently included *Cyclochorus maculatus* in the synonymy of *Cyclochorus lineatus*.

Castro de Elera (1895) reported *Hologerrhum philippinum* from Baco, Mindoro Island. This important specimen could not be examined as it was destroyed during dissections by a biology class at the University of Santo Thomas, Manila (R. I. Crombie, personal communication) but the "Mindoro" locality information suggests a misidentification of a specimen of *C. lineatus* (Taylor, 1922a; Leviton, 1963, 1965). Griffin (1910) did not include *Hologerrhum* in his list of snakes from Polillo but did include the species in his key to the Philippine snakes (Griffin, 1911), although he erred in attributing the type description to Boulenger and supplied no precise locality data.

It was not until E. H. Taylor's extensive work in the Philippines that specimens of *H. philippinum* with reliable locality data became available. Taylor (1922a, 1922b, 1922c, 1922d) consistently reported that this species was collected in montane habitats in primary forest and usually was associated with rocky stream beds on Luzon and its land-bridge satellite island of Polillo (Fig. 2). Still, Taylor (1922b:200) considered the species rare and only obtained eight specimens in two years of nearly continuous field work.

During the nearly 80 years that have elapsed since Taylor's work, several additional specimens of *H. philippinum* have been collected on Luzon and its associated land-bridge islands (Marinduque, Polillo, and Catañduanes; see Specimens Examined; Fig. 2). During the same period, none have been found on Mindanao, Mindoro, or any of the other Philippine islands, thus bolstering the notion that *H. philippinum*

is endemic to the Luzon Pleistocene Aggregate Island Complex (Fig. 2; *sensu* Heaney, 1986; Alcalá, 1986; see also comments by Leviton, 1963).

In 1992, while participating in the National Museum of the Philippines/Cincinnati Natural History Museum Philippine Biodiversity Inventory (PNM/CMNH PBI), one of us (RMB) collected specimens of what appeared to be a distinctive new species of snake, similar to but obviously specifically distinct from *H. philippinum*, at 1025 m elevation on the west face of Mt. Madja-as, Panay Island. In addition to representing a previously unrecognized species, this specimen appears to be the first vouchered record for the genus on the Visayan Aggregate Island Complex (Fig. 2; Heaney, 1986; Hall, 1996, 1998). During the course of this study we examined all available US and Philippine museum collections of *H. philippinum* and

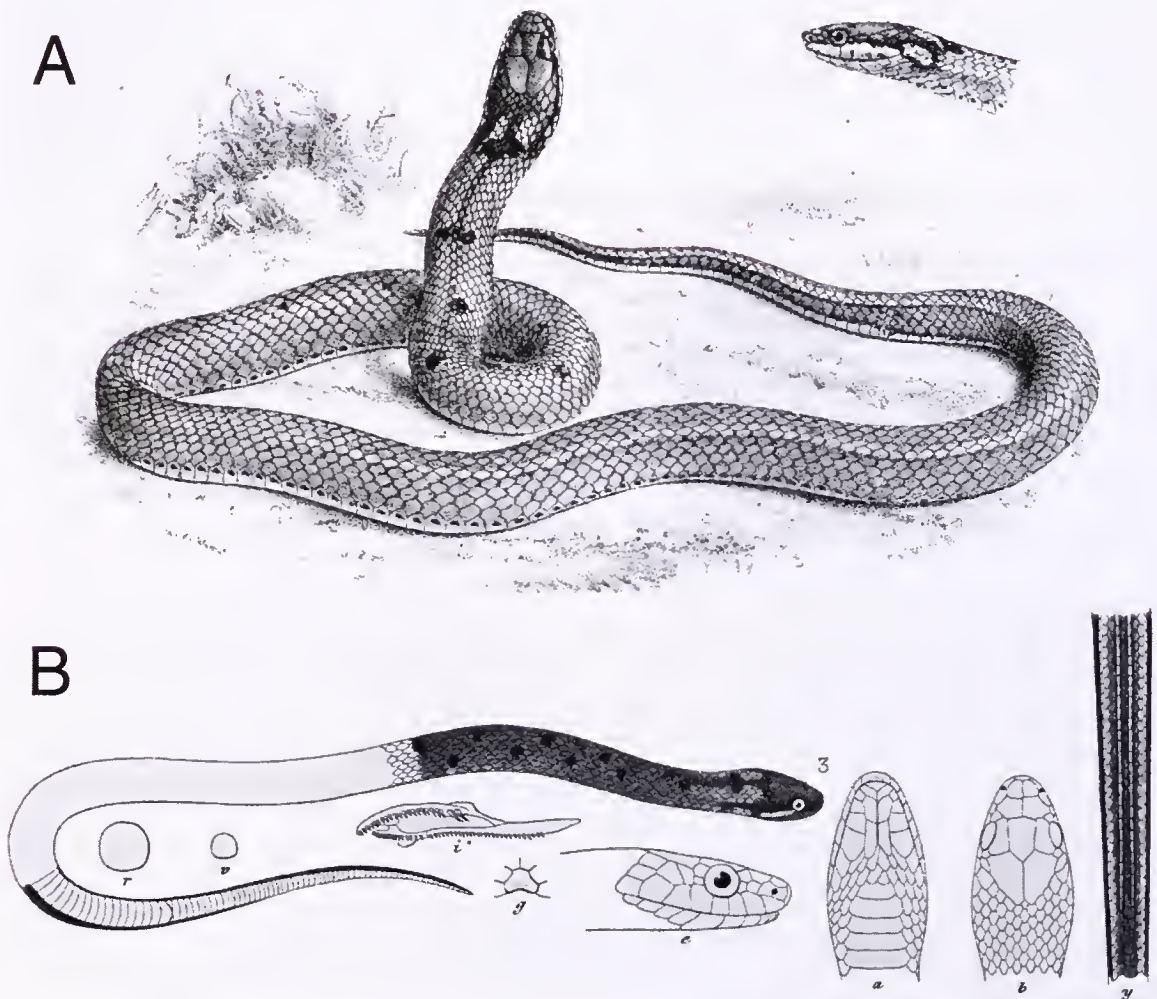


Figure 1. The first illustrations of *Hologerrhums*. (A) Günther's (1879) drawings of *H. philippinum* and (B) Sordelli's plate of *Cyclochorus maculatus* (= *H. philippinum*) from Jan and Sordelli (1870).

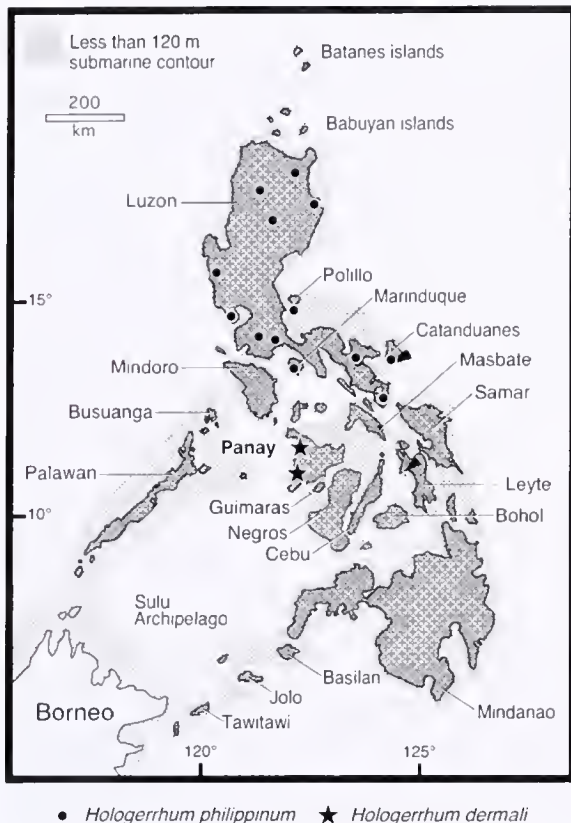


Figure 2. Map of the Philippine islands with the major Pleistocene aggregate island platforms indicated by the position of the 120 m underwater bathymetric contour (following Heaney, 1986); known collection localities of the two species of *Hologerrhum* are indicated. Darkened circles represent collection localities for *Hologerrhum philippinum* Günther, 1858, stars are localities for *Hologerrhum dermali* new species.

Hologerrhum n. sp. In this paper, we redescribe *H. philippinum* and describe the new species from Panay.

Material and Methods

We surveyed the forested slopes of Mt. Madja-as from 6 April–1 May 1992, utilizing elevational transects as described by Ruedas et al. (1994) and as modified by Brown et al. (1995, 1996, in press; Ferner et al., this issue). Sampling techniques employed a variety of search and trapping methods, including multiple-person time-constrained searches, sticky traps, and pit-fall traps (Simmons, 1987). Specimens were fixed in 10% buffered formalin and transferred to 70% ethanol approximately 2 months following preservation.

Museum specimens (see Specimens Examined, below) were examined for color pattern and scale character differentiation and only data scored by RMB and AEL were used in an effort to minimize inter-observer sources of variation (Lee, 1990). We

used Dowling's (1951a, 1951b) methods for counting scales and expressing scale row reduction formulae, and applied the Evolutionary Species Concept (Simpson, 1961; Wiley, 1978; Frost and Hillis, 1990) in making taxonomic decisions.

Species accounts

Hologerrhum philippinum Günther 1858

Figures 3–6

Hologerrhum philippinum. Günther (1858:186).

Cyclochorus maculatus. Jan and Sordelli (1870:36; generic name misspelled; the specimen illustrated is *H. philippinum* with doubtful locality data).

Hologerrhum philippinum. Günther (1873: 171; specimen is a member of the genus *Cyclocorus*, vide Boulenger, 1896).

Cyclochorus lineatus var. *maculatus* Fischer, 1885:81.

Hologerrhum philippinum. Boettger (1886:115) Castro De Elera (1895:438; specimen probably *Cyclocorus lineatus*); Boulenger (1896:33); Taylor (1922a:116; 1922b:200, 1922c:138); Ross and Gonzales (1991:67); Brown et al. (1996:13).

Hologerrhum philippinum Griffin, 1911:263 (generic name misspelled).

Diagnosis: *H. philippinum* differs from its congener, *H. dermali*, by (1) the presence of 12–30 (vs. 7–10) pairs of alternating black spots on nuchal region and anterior dorsum, (2) a pale orange to salmon (vs. bright yellow) venter, (3) absence (vs. presence) of a black midventral stripe, (4) labials cream or yellow (vs. labials bright white with thin midlabial black stripe), (5) dorsum tan to orangish brown or dark brick red (vs. dark purplish brown), (6) chin and throat of adults pale tan to orange, immaculate or with faint white spots in some specimens (vs. darker purplish brown with black and white ocelli), (7) invariable presence of moderate to enlarged pretemporal (length more than half that of secondary temporal; vs. pretemporal reduced or absent), and (8) posterior tips of parietals extend caudally, posterior parietal suture forming a medially inverted V-shaped cleft (vs. posterior portions of parietals squared off, with no medial cleft).

Description: Body cylindrical, ventrals convex, head slightly distinct from neck, not flattened; eyes small, pupil round; vertebral ridge absent.

Rostral scale much broader than deep, scarcely visible from above, subtriangular with ventromedial groove in dorsal aspect; nasal divided, naris piercing



Figure 3. Live photograph of *Hologerrhum philippinum* from the Zambales Mountains of western Luzon Island (female, PNM 2490; photograph copyright D. Wechlser).

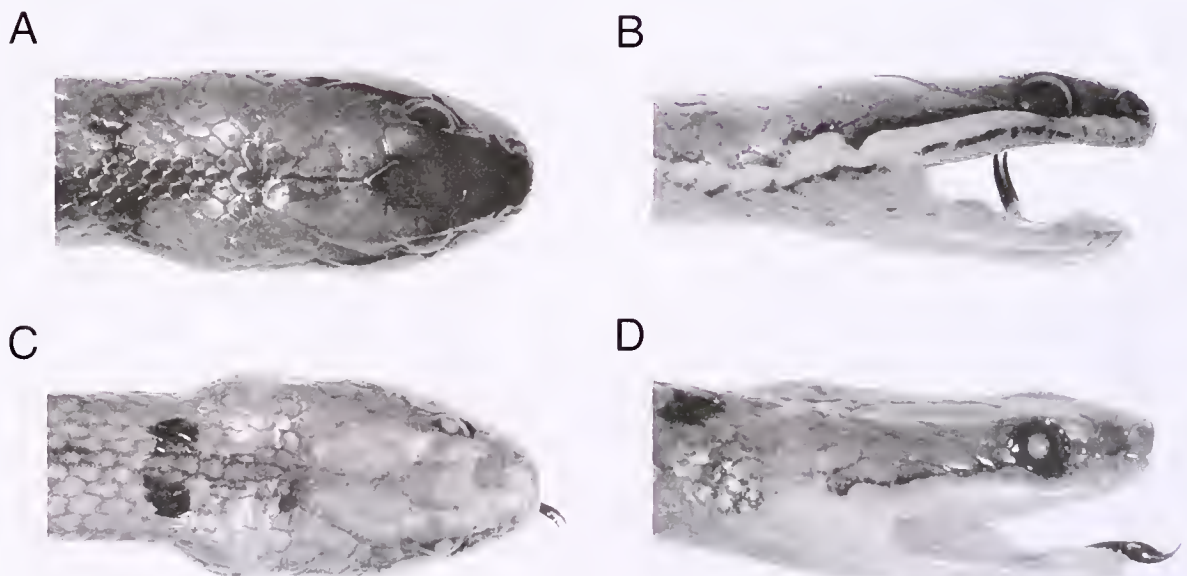


Figure 4. (A) Dorsal and (B) lateral view of the head of *Hologerrhum dermali* (CMNH 5075); (C) dorsal and (D) lateral view of the head of *Hologerrhum philippinum* (PNM 2490).

Table 1. Summary of diagnostic characters distinguishing *Hologerrhum dermali* (new species; from Panay Island) from *Hologerrhum philippinum* (Günther, 1858; from the Luzon Aggregate Island Complex).

Characters	<i>H. philippinum</i>	<i>H. dermali</i>
Pretemporals	enlarged	reduced or absent
Ventral nuchal blotches	–, +	–
Lateral black ventral spots	–, +	+, fused into line
Dorsal nuchal spots	12–30	7–10
Midlabial stripe	–	+
Dorsal live color	tan to reddish brown	purplish brown
Ventral live color	orange to salmon	bright yellow
Adult throat color	tan to orange (some spotted white)	purplish brown with black and white ocelli
Midventral dark stripe	–	+
Parietal suture	notched	unnotched
Ventral scale at 2nd dorsal reduction	97–112*	84–97
Subcaudals (females)	42–53	57–61

* Excluding apparently aberrant counts of CAS 61554 (Table 2).

suture between pre- and postnasal; together, nasal scales square to triangular; dorsal border of nares formed by thick shelf of prenasal, ventral border formed by extension of postnasal; internasals as long as broad, slightly shorter than prefrontals, laterally contacting both pre- and postnasals, forming a vague right triangle with 45° face oriented anterolaterally; loreal single, as large as or only slightly smaller than ventral preocular, half as high as postnasal, pentagonal, surrounded by postnasal, lateral edge of prefrontal, dorsal and ventral preoculars, and second supralabial; prefrontals longer than internasals, with irregular lateral extensions caused by presence of concave curved suture with preoculars (concave surface oriented posterolaterally); frontal twice as long as broad, longer than to equal to its distance to the end of the snout, shorter than parietals; anterolateral corner of frontal barely contacting medial point of preocular (e.g., CAS 31553, 60951, MCZ R-25693–94, PNM 6505), or with substantive contact between frontal and preocular squeezed off by contact between supraocular and prefrontal (e.g., CAS 60950, 61554, 62430, 134075; PNM 2120, 2490; USNM 498718, MCZ R-25695); posteromedial point of frontal extends past posterior margin of supraoculars for distance shorter than or equal to length of internasals; supraoculars very large, nearly as long as and slightly narrower

than frontal; parietals very large, laterally contacting dorsal postocular, pretemporal, and highly enlarged secondary temporal, together bordered posteriorly by three (CAS 61554, 134075), four (CAS 60950, 61553; USNM 498718, MCZ R-25695) or five (CAS 60951, 62430; PNM 2490, MCZ R-25693–94) undifferentiated nuchals; posterior tips of parietals extend caudally, parietal suture forming a distinct medially inverted V-shaped cleft, in which a single slightly enlarged to undifferentiated nuchal (Fig. 6) lies; temporals arranged in three to four irregular vertical rows with enlarged posttemporals extending caudally beyond posterior ends of parietals; temporal formulae: (L) 2/1+1/1+2, (R) 1+1+1/1+2 (PNM 2490), (L, R) 1+2+1/1+2 (CAS 60950), (R, L) 1+1+2+3 (MCZ R-25695), (L) 1+1+2+3, (R) 1+1+2+2 (CAS 60951), (L) 1+1+2+3, (R) 1+1+2+4 (MCZ R-25694) (L) 1+1+1/1+2, (R) 1+1+2+3 (CAS 61554, PNM 6505), (L, R) 1+1+1/1+2 (CAS 62430, 61558, 134075; USNM 318363, 498718; TNHC 60114, MCZ R-25693, PNM 2120), (L) 1+1+2+3, (R) 2+1/1+2 (USNM 319037), (L); pretemporal relatively enlarged, its length much more than half that of secondary temporal.

Orbit surrounded by supraocular, two preoculars (dorsal larger than ventral), two postoculars, and supralabials 3–5; supralabials eight, fifth largest;

Table 2. Scale row reduction formulae (Dowling, 1951b) variation in *H. philippinum philippinum* (Günther, 1858; from the Luzon Aggregate Island Complex) and the type series of *H. dermali* (new species; from Panay Island).

Specimen (sex)	Reduction 1	Reduction 2
<i>Hologerrhum philippinum</i>		
CAS 60951 (juv.)	$19 \frac{3+4=3(4)}{4+5=4(5)} 17$	$17 \frac{3+4=3(107)}{3+4=3(106)} 15$
CAS 60950 (juv.)	$19 \frac{4+5=4(5)}{3+4=3(4)} 17$	$17 \frac{3+4=3(103)}{3+4=3(105)} 15$
CAS 61553 (f)	$19 \frac{3+4=3(7)}{4+5=4(5)} 17$	$17 \frac{3+4=3(109)}{3+4=3(112)} 15$
CAS 61554 (f)	$19 \frac{3+4=3(7)}{4+5=4(6)} 17$	$17 \frac{3+4=3(93)}{3+4=3(95)} 15$ $+4(96)$ $3+4=3(100)$
CAS 62430 (juv.)	$19 \frac{3+4=3(7)}{3+4=3(6)} 17$	$17 \frac{3+4=3(101)}{3+4=3(103)} 15$
PNM 2490 (f)	$19 \frac{3+4=3(16)}{5+6=5(5)} 17$	$17 \frac{3+4=3(110)}{4+5=4(109)} 15$
PNM 2120 (f)	$19 \frac{5+6=5(5)}{5+6=5(6)} 17$	$17 \frac{3+4=3(95)}{-4(99)} 15$
PNM 2120 (juv)	$19 \frac{3+4=3(4)}{3+4=3(4)} 17$	$17 \frac{3+4=3(97)}{-4(96)} 15$
USNM 319037 (f)	$19 \frac{3+4=3(6)}{3+4=3(5)} 17$	$17 \frac{3+4=3(105)}{3+4=3(109)} 15$
USNM 318363 (f)	$19 \frac{3+4=3(5)}{3+4=3(7)} 17$	$17 \frac{3+4=3(100)}{3+4=3(99)} 15$
USNM 498718 (m)	$19 \frac{3+4=3(5)}{3+4=3(5)} 17$	$17 \frac{-4(100)}{-4(105)} 15$
TNHC 60114 (f)	$19 \frac{3+4=3(5)}{3+4=3(8)} 17$	$17 \frac{3+4=3(102)}{-4(100)} 15$
MCZ R-25693 (f)	$19 \frac{4+5=4(4)}{3+4=3(4)} 17$	$17 \frac{3+4=3(100)}{3+4=3(100)} 15$

Table 2. (continued)

Specimen (sex)	Reduction 1	Reduction 2
MCZ R-25694 (f)	$19 \frac{4+5=4(4)}{4+5=4(4)} 17$	$17 \frac{3+4=3(102)}{3+4=3(103)} 15$
MCZ R-25695 (juv)	$19 \frac{5+6=5(8)}{5+6=5(6)} 17$	$17 \frac{3+4=3(97)}{3+4=3(100)} 15$
Mean	$\bar{x} = 6.3 \pm 3.2 \text{ SD}; n = 12$ $\bar{x} = 5.5 \pm 1.2 \text{ SD}; n = 12$	$\bar{x} = 102.2 \pm 4.9 \text{ SD}; n = 12$ $\bar{x} = 103.6 \pm 4.9 \text{ SD}; n = 12$
<i>Hologerrhum dermali</i>		
PNM 2711 H (f)	$19 \frac{3+4=3(5)}{3+4=3(6)} 17$	$17 \frac{3+4=3(94)}{3+4=3(92)} 15$
PNM 6505 P (f)	$19 \frac{-4(3)}{3+4=3(6)} 17$	$17 \frac{-4(97)}{-4(92)} 15$
CMNH 5075 P (f)	$19 \frac{3+4=3(5)}{3+4=3(7)} 17$	$17 \frac{3+4=3(84)}{3+4=3(84)} 15$
Mean	$\bar{x} = 4.3 \pm 1.2 \text{ SD}; n = 3$ $\bar{x} = 6.3 \pm 0.6 \text{ SD}; n = 12$	$\bar{x} = 91.7 \pm 6.8 \text{ SD}; n = 12$ $\bar{x} = 89.3 \pm 4.6 \text{ SD}; n = 12$

H = Holotype; P = Paratype

infralabials eight; mental subtriangular, with highly pointed posterior tip caused by medially concave curved suture with first infralabial; first infralabials differentiated, elongate, with curved medial points nearly contacting anterior to genials; second infralabials reduced, squarish; infralabials 2–5 increasing dramatically in size (fifth largest in ventral aspect), then decreasing sharply to infralabial 8; infralabials 1–4 in contact with anterior genials, 4–5 in contact with pos-

terior genials; mental groove distinct and broad; sublabials thin, followed medially by 3–4 similarly-sized, longitudinal rows of gulars, medial two pairs (anterior to first ventral) slightly enlarged; number of gular pairs between posterior genials and first ventral two (CAS 61553) or three (remaining specimens).

Dorsals smooth, without apical pits, vertebrae undifferentiated from paravertebrals, in 146–176 ($\bar{x} = 157.4 \pm 8.1 \text{ SD}; n = 12$) transverse rows on body, 42–

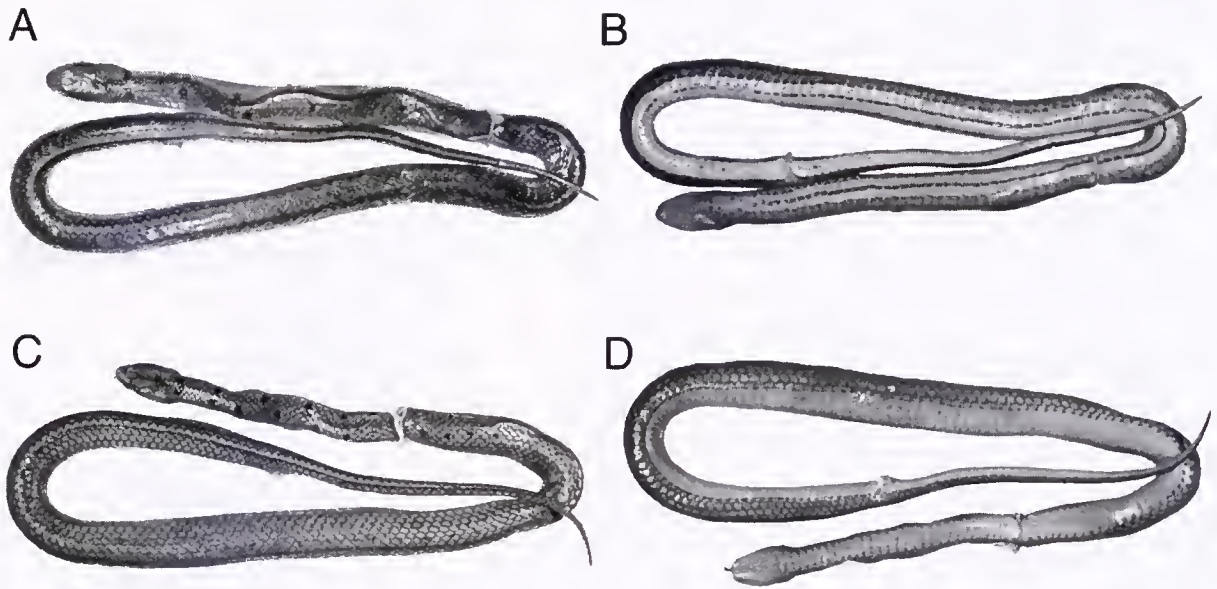


Figure 5. (A) Dorsal and (B) ventral view of a paratype of *Hologerrhum dermali* (CMNH 5075); (C) dorsal and (D) ventral view of *Hologerrhum philippinum* (PNM 2490).

56 ($\bar{x} = 49.3 \pm 5.3$ SD; $n = 12$) on tail; first scale row reduction (i.e., reduction of 19 to 17 scales around body; Table 2) occurring at point on body corresponding to ventrals 4–16 (left: $\bar{x} = 5.5 \pm 1.2$ SD; $n = 12$; right: $\bar{x} = 6.3 \pm 3.2$ SD; $n = 12$), second (17 to 15) occurring between ventrals 93–110 (left: $\bar{x} = 103.6 \pm 4.9$ SD; $n = 12$; right $\bar{x} = 102.2 \pm 4.9$ SD; $n = 12$); ventrals broad, each slightly angulated laterally, 136–158 ($\bar{x} = 146.7 \pm 6.4$ SD; $n = 12$); subcaudals 42–56 ($\bar{x} = 47.5 \pm 4.6$ SD; $n = 12$). The single adult male specimen (USNM 498718) has 156 vertebrae, 149 ventrals, 56 caudals, and 55 subcaudals. Anal undivided; tail with enlarged vertebral row (dorsocaudals) formed by fusion of midvertebral row with both flanking paravertebral rows. Hemipenes of USNM 498718 are extremely narrow and elongate, and are covered with uniformly minute spines; hemipenes extend *in situ* to the 14th subcaudal plate.

Measurements (in mm): SVL 251–347 mm ($\bar{x} = 280.8 \pm 47.1$ SD) for ten mature females; tail length $\bar{x} = 56$ –96 ($\bar{x} = 73.8 \pm 15.0$ SD) for eight mature females with complete tails.

Coloration in preservative: Dorsum tan, orangish-tan to brown, with 12–30 ($\bar{x} = 21.8 \pm 7.5$ SD; $n = 12$) alternating dark brown to black spots (Figs. 1A, 3, 5C), each with three associated small white spots (Fig. 3), fading in intensity posteriorly, where they are

replaced on scale rows 4–5 by a pair of dorsolateral black lines, gaining intensity posteriorly and continuing to tip of tail; faint vertebral thick gray stripe (1–3 scales in width) becoming increasingly apparent posteriorly from midbody; a pair of light cream lines dorsal (medial) to black lines; posterior (distal) portions of each dorsal scale slightly to markedly darker than remainder of scale; dorsal occiput colored as body (PNM 2490) or slightly darker (CAS 60950) to markedly darker (CAS 134075); melanic pigment congregated on medial suture between parietals, on posterior portion of frontal, and on lateral edge of head; distinct longitudinal dark midnuchal stripe evident from posterior edge of parietals to second pair of nuchal spots (Fig. 1A), occasionally (e.g., juveniles CAS 134075 and MCZ R-25695, adult female USNM 318363) very dark and forming a distinct nuchal cross (Fig. 1B); one specimen with a pair of bright white nuchal spots immediately anterior to nuchal cross (USNM 319037; Fig. 1A); lateral aspects of head colored as dorsal, with distinct thin black line dorsally bordering supralabials (Fig. 4D) and stretching from tip of snout to just beyond supralabial 8; labials creamy yellow to tan, occasionally with a few black flecks (CAS 60950) or with ventral half of labials dark gray (USNM 319037); venter immaculate cream to pale yellow or orange; each ventral with dark lateral pigment in the form of a small black spot or brown to black longitudinal bar (Figs. 1A, 3), becoming a confluent black ventrolateral stripe on posterior portions of body and tail; some specimens with subtriangular black mark-

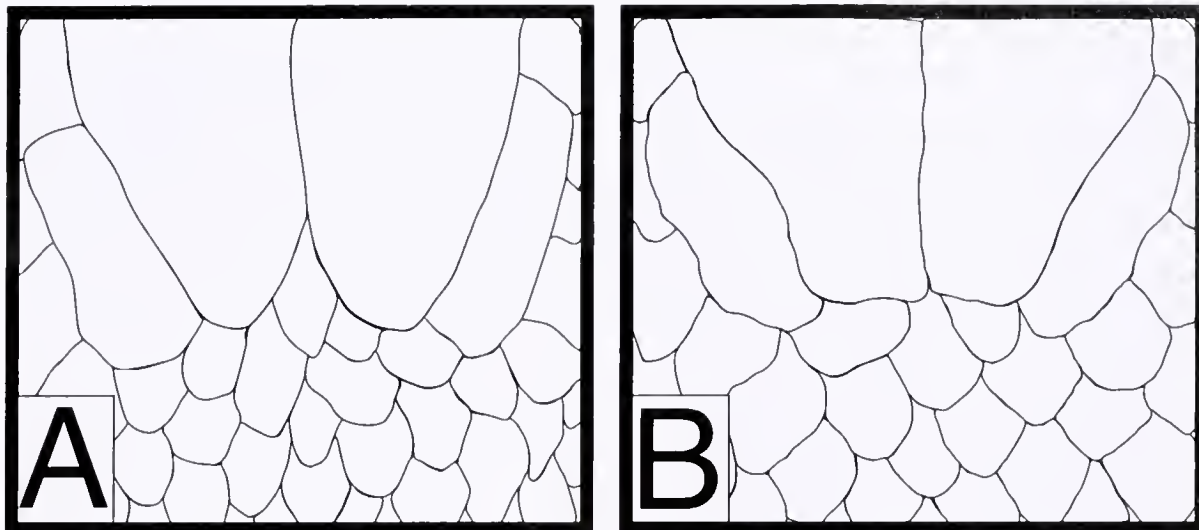


Figure 6. Comparison of the posterior portions of the parietal suture in (A) *Hologerrhum philippinum* (PNM 2490) and (B) *Hologerrhum dermali* (CMNH 5075).

ings on anterior 20 ventrals (USNM 319037, 498718; TNHC 60114); underside of head lighter (PNM 2490), to distinctly darker (USNM 319037) than remainder of venter, especially in juvenile specimens (MCZ R-25694-95; CAS 134075) where ventral head coloration resembles that of adult *Hologerrhum* n. sp. (see below); tongue black with pale gray tips of bifurcated portions.

Coloration in life: (Fig. 3) Dorsum described as “bright reddish to orange brown, darker anteriorly” or “reddish brown” (Taylor 1922b:200) or “grayish brown on neck, fading to orangish brown posteriorly” (Brown et al., 1996:13); labials dirty white to creamy yellow; venter “uniform pale, orangish tan” (Brown et al., 1996:13) to “bright reddish salmon, lighter anteriorly” or “uniform coral to red” (Taylor, 1922b:200); underside of head pale orange to “dusky with milk white spots” (Taylor, 1922b:200).

Hologerrhum dermali, n. sp.

Figures 4–6

Holotype: PNM 2711, an adult female, collected at 0900 hr on 9 April, 1992 by Rafe M. Brown at 1510 m above sea level in the area known locally as “Hang-gud Tubig” (“Big Water”), on the western face of Mt. Madja-as, Barangay Alojipan, Municipality of Culasi, Antique Province, Panay Island, Philippines (11°23' N, 122° 09'E).

Paratypes: CMNH 5075, an adult female, same data as the holotype except collected at 1030 hr on 6 April 1992 by Rogelio V. Sison; PNM 3704, an adult female, collected February–March 1994 by Rogelio V. Sison at 750 m above sea level on Mt. Ranges, Sitio

Banagon, Barangay Aningalan, Municipality of San Remegio, Antique Province, Panay Island, Philippines.

Etymology: The specific epithet is chosen to honor Ronald “Dermal” Crombie, in recognition of his numerous contributions to Philippine herpetology and in thanks for the guidance he has provided RMB and JWF during the past several years of our work with Philippine amphibians and reptiles.

Diagnosis: *Hologerrhum dermali* can be readily distinguished from its congener, *H. philippinum*, by (1) the presence of 7–10 (vs. 12–30) pairs of dark spots in nuchal and dorsal regions, (2) a bright yellow (vs. pale orange to reddish salmon) venter, (3) presence (vs. absence) of a black midventral stripe, (4) bright white labials with midlabial black stripe (vs. cream or yellow labials; midlabial stripe absent), (5) dorsum dark purplish brown (vs. tan to dark orangish brown or dark brick red), (6) chin and throat of adults dark purplish brown with black and white ocelli (vs. pale tan to orange, immaculate or with faint white spots in some specimens), (7) pretemporal absent or much reduced (length less than half that of secondary temporal; vs. pretemporal invariably present and enlarged), and (8) posterior portions of parietals squared off, with no medial cleft at parietal suture (vs. posterior tips of parietals pointed, extending caudally to form a medial inverted V-shaped cleft).

Description of the Holotype: An adult female. Body cylindrical, ventrals convex, head slightly distinct from neck, not flattened; eyes small, pupil round; vertebral ridge nonevident.



Figure 7. Habitat of *Hologerrhum dermalis* at the type locality (following heavy rain).

Rostral much broader than deep, barely visible from above, subtriangular with ventromedial groove in dorsal aspect; nasal divided, naris piercing suture between pre- and postnasal; majority of dorsal border of nares formed by prenasal, majority of ventral formed by postnasal; internasals as long as broad, slightly shorter than prefrontals, laterally contacting both pre- and postnasals, forming a vague right triangle with 45° face oriented anterolaterally; loreal single, distinctly smaller than ventral preocular, half as high as postnasal, pentagonal, surrounded by postnasal, lateral edge of prefrontal, dorsal and ventral preoculars and second supralabial; prefrontals longer than internasals, with irregular lateral extensions caused by presence of concave curved suture with preoculars (concave surface oriented posterolaterally); frontal twice as long as broad, longer than its distance to the end of the snout, a little shorter than parietals; frontal-preocular contact squeezed off by substantive contact between posteriolateral corners of prefrontals and anteromedial corner of supraocular; posteromedial point of frontal extends past posterior margin of supraoculars for distance shorter than length of internasals; supraoculars very large, nearly as long as and narrower than frontal; parietals very large, laterally contacting dorsal postocular, pretem-

poral, and highly enlarged secondary temporal, together bordered posteriorly by five undifferentiated nuchals; posterior ends of parietals squared off, with no medially inverted V-shaped cleft at parietal suture (Fig. 6); enlarged posttemporals extend posteriorly only slightly beyond caudal margin of parietals; temporals (L) $1+1+2+3$, (R) $1+1/1+2$ (pretemporal much reduced, its length much less than half that of suture between parietal secondary temporal).

Orbit surrounded by supraocular, two preoculars (dorsal larger than ventral), two postoculars, and supralabials 3–5; supralabials eight, fifth largest; infralabials eight; mental subtriangular, with highly pointed posterior tip caused by medially concave curved suture with first infralabial; first infralabials differentiated, elongate, with curved medial points nearly contacting anterior to genials; second infralabials reduced, squarish; infralabials 2–5 increasing dramatically in size (fifth largest in ventral aspect), then decreasing sharply to infralabial 8; infralabials 1–4 in contact with anterior genials, 4–5 in contact with posterior genials; mental groove distinct; sublabials thin, followed medially by four similarly-sized, longitudinal rows of gulars, medial two pairs (anterior to first ventral) enlarged; two pairs of gulars between posterior genials and first ventral.

Dorsals smooth, without apical pits, vertebrals undifferentiated from paravertebrals, in 140 transverse vertebral rows on body, 64 on tail; scale row reduction from 19 to 17 in nuchal region and from 17 to 15 posterior to midbody (Table 2); ventrals 143, broad, each slightly angulated laterally; subcaudals 61; anal undivided; tail with enlarged vertebrals formed by fusion of midvertebral row with both flanking paravertebral rows; SVL 220 mm; tail length 68 mm.

Coloration in preservative: Dorsum dark purplish brown with 10 tightly paired black spots, decreasing in size posteriorly (Fig. 5A) on anterior one third of body; caudal third of body with a pair of dorsolateral black lines (on scale rows 4–5) gaining intensity posteriorly and continuing to tip of tail; vertebral stripe absent; a pair of light, bright yellowish lines dorsal (medial) to black lines, especially bright on tail; posterior (distal) portions of each dorsal scale markedly darker than remainder; dorsal occiput colored as body; melanin pigment congregated on medial suture between parietals, on posterior half of frontal, and on lateral edge of head; supralabials bright white, dorsal border composed of thin black stripe (Fig 4B), from tip of rostrum to beyond angle of jaw; white labial coloration continues in the form of a broad white stripe to point opposite fifth ventral; midlabial thin black stripe (Fig 4B) continues posteriorly as ventral border of the white stripe in nuchal region; distinct dark brown midnuchal stripe evident from posterior edge of parietals to first pair of nuchal spots, very dark and confluent with nuchal spots, forming a distinct nuchal cross; chin and throat purplish brown with white circular spots encircled in black (ocelli) much like juvenile coloration in *H. philippinum* specimens; venter pale yellow with midventral thin black stripe, becoming interrupted on caudal portions of body, nearly obliterated by vent and continuing again caudal to vent for five ventrals; each ventral with dark lateral pigment in the form of a small black spot (anteriorly) or black longitudinal bar (caudally), becoming a confluent black ventrolateral stripe on caudal portions of body and tail; tongue black with bright white tips on forked portions.

Coloration in life: Dorsum and ventral surfaces of head light purplish brown, light areas dorsal (medial) to dorsolateral caudal lines medium yellow; labials bright milky white; venter very bright yellow with distinct black midventral stripe. Iris dark brown to brick red.

Variation: One paratype (female, CMNH 5075, SVL 268 mm; tail 91 mm) has seven pair of dark dorsal spots, slightly lighter midcephalic coloration and

less yellow above the dorsolateral caudal black lines. The midventral black stripe continues to the tenth subcaudal. This specimen lacks the small pretemporals found in the holotype; temporals (R, L) 1+1/1+2; ventrals 143, subcaudals 60, vertebrals 156, dorsocaudals 64. The other paratype (female, PNM 3704, SVL 327 mm; tail 93 mm) has nine pairs of nuchal spots, a faint midlabial line, and lacks midventral stripes on the subcaudals (present on anterior 2/3 of body). PNM 3704 has the following counts (R, L) 1+1+2+3, 1+1+1/1+2; ventrals 149; subcaudals 58; vertebrals 155; dorsocaudals 57. Scale row reduction formula presented in Table 2.

Ecology and habitat: The type of habitat in which *H. dermali* (Fig. 7) was collected on Mt. Madja-as has been classified as the transition zone between mixed dipterocarp (submontane) and mossy (upper montane) forests (Whitmore, 1984; Ferner et al., 1997). The forest consisted of two strata (a canopy of 10 m, and a subcanopy of 3–4 m with emergent trees as high as 18 m); herb and shrub layer vegetation was also abundant. The forest near the collection site was mossy and contained high densities of epiphytic ferns and orchids. Topography was qualitatively characterized as steep, with numerous valleys bordered by sheer rock escarpments and forest-covered ridges. The holotype was collected in a sun spot in the early afternoon in a rocky stream bed (10 m wide) with a central 4 m wide channel of rapidly running water. The specimen was basking 1.5 m from water on the top of a flat rock. The Mt. Madja-as paratype was collected in the mid-morning and was crawling through leaf litter on the forest floor (30 m from the same stream) when captured. Paratype PNM 3704, collected in San Remegio, was found on the floor of secondary forest near a small dry stream bed. The circumstances of collection are very similar to those reported for *H. philippinum* on Luzon (Taylor, 1922b; Brown et al., 1996; A. Diesmos, personal communication).

Discussion

The endemic Philippine genus *Hologerrhum* is now known to contain two species distributed on the Luzon and Visayan aggregate island complexes (Fig. 2). There are no known *Hologerrhum* from the Palawan, Mindoro, Mindanao, Sulu Archipelago, or the Batanes faunal subregions (Fig.2).

The absence of any clear close relatives of *Hologerrhum* (Leviton, 1963, 1965) among SE Asian colubrids renders speculations regarding the genus' affinities somewhat moot. However, we note that both *Hologerrhum* and *Cyclocorus* share characteristics

unique among Asian snakes, most notably, an unusual, presumably derived pattern of reduction in caudodorsal scale rows. In all species of *Cyclocorus* and *Hologerrhum*, caudodorsal reduction takes place by fusion of vertebral and paravertebral scale rows, resulting in an odd-numbered series of longitudinal rows of caudodorsals rather than an even number (characteristic of all other SE Asian colubrine snake genera known to us). The systematic affinities of the genus *Hologerrhum* are in need of further study.

The description of *Hologerrhum dermali* brings the number of new species of vertebrates recently described by the PNM/CMNH PBI team in the coastal Madja-as mountain range to six (Sison et al., 1995; Gonzales and Kennedy, 1990, 1996; Brown et al., 1997; Ferner et al., 1997; Brown et al., 1999). Other collections from Panay contain at least three probable undescribed species of frogs and many other species of amphibians and reptiles of uncertain taxonomic status (many of which are, doubtlessly, undescribed species; Ferner et al., this issue). Most of these species presumably are reliant on the closed-canopy rain forests of the western portions of Panay. Accordingly, most should be considered severely threatened by deforestation (see Ferner et al., 1997:fig. 2). Recent survey work in the northwestern portions of Panay indicates that *Hologerrhum dermali* occurs in forested habitats at lower elevations as well as the montane localities reported here (M. Gaulke, personal communication). Unfortunately, the low elevation forests of Panay Island have nearly all been removed by an aggressive timber industry in the central Visayas. We expect that numerous other undescribed populations of amphibians and reptiles will be discovered in Panay and the remainder of the Visayas if biologists are permitted access to these forests in order to catalog and describe Philippine biodiversity.

Specimens Examined

Hologerrhum philippinum: Philippines, Luzon Island, Zambales Province, Municipality of Masinloc, Barangay Coto, 4.3 km N, 0.5 km E of Mt. High Peak, elevation 1550 m (15° 31' N, 120° 07' E): PNM 2490; Bataan Prov., Mt. Mariveles: CAS 60950–51; Isabela Prov., Municipality of Palanan, Barangay Didian, Sitio Natapdukan, elevation 50 m: PNM 6505; Kalinga Prov., Municipality of Balbalan, Barangay Balbalan: CAS 61553–54, MCZ R-25694; Caminanes Sur Prov., Municipality of Naga City, Mt. Isarog, elevation 900 m: USNM 31863; Cagayan Prov., Municipality of Baggao, Barrio Santa Margarita, elevation 150 m: USNM 319037, 498718; CAS 134075; Quezon Prov., Municipality of Tayabas, Barangay Camaysa,

Mt. Banahaw, 1150 m above sea level: TNHC 60114 Camarines Norte Prov., Municipality of Ruis, Barangay San Lorenzo, Mt. Labo Range: PNM 2120; Mountain Prov., Mt. Polis: PNM 67; Laguna Prov., Mt. Makiling: MCZ R-25695; Polillo Island, Polillo Prov., near town of Polillo: CAS 62430, MCZ R-25693; Catañduanes Island, Municipality of Gigmoto, Barangay Summit Bordan, elevation 200 m: USNM 319037.

Hologerrhum dermali: See Holotype and Paratypes sections for this species.

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The First Record of *Ptyas korros* (Colubridae) from Bangladesh

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Abstract.— This is the first report of *Ptyas korros* from Bangladesh. The specimens reported here were collected from the Chittagong University campus between the years of 1985 and 1996. They match previously described specimens of *Ptyas korros* except in the number of loreal scales. *Ptyas korros* is known to occur in the Assam region of India and so its presence in adjacent regions of Bangladesh is expected, but unconfirmed until now.

Key words.— Serpentes, Colubridae, *Ptyas korros*, Bangladesh, distribution, biogeography

The number of species of snakes occurring in Bangladesh is still debatable because of the lack of confirmation of some species. However, lists have been compiled based on a number of field studies conducted in different parts of the country. Sarker (1975) recorded 20 species, Montaquim (1979) reported 18 species, Montaquim et al. (1980) recorded 28 species and Rashid (1982) recorded 22 species from Bangladesh. Whereas Khan (1982) estimated the snakes species of the country as 78 and he later reported 79 species in 1987 and 81 species in 1992 (of which the occurrence of two are doubtful). Sarker and Sarker (1988) reported 88 species, although some are uncertain. This report established the presence of one species, *Ptyas korros* (Schlegel, 1837).

During the identification of the snake species preserved in the Departmental Museum of Zoology, Chittagong University (CU), four specimens (three

collected from CU Campus [CUC] between 1985 and 1996, and one not known but possibly from CUC) of *P. korros* were found (Fig. 1). Until now, nobody has reported the occurrence of *P. korros* in Bangladesh, although Husain (1977) predicted it. Its known range extends from Assam (India) through Myanmar (Burma) to Indo-China, Thailand, throughout the Tenasserim to the Malay Peninsula, Indonesia (Sumatra, Java, Borneo), Southern China including Hainan, Taiwan and Hong Kong (cf. Günther, 1864; Smith, 1943; Zhao & Adler 1993). The occurrence of *P. korros* in the CUC, Chittagong, extends its distribution to Bangladesh. It might also occur in nearby parts of the country such as Jamalpur, Greater Sylhet, Chittagong, Chittagong Hill Tracts (Rangamati, Khagrachari and Bandarban Districts).

The specimens from the CUC are olive brown above and yellowish white below. The scales on the posterior part of the dorsal side of the body are edged with a dark brown pattern (looking black) producing a regular network pattern. The outer margins of the ventrals and caudals are also sometimes edged with dark brown (less dark than the dorsal color). The coloration of the CUC specimens resembles the *P. korros* specimens described by Smith (1943). Smith (1943) diagnoses *P. korros* from *Ptyas muscosus* by the number of dorsal scale rows (15 in *P. korros* vs. 16 or 17 in *P. muscosus*) and the number of ventral scales (160-187 in *P. korros* vs. 190-213 in *P. muscosus*). The CUC specimens have 15 dorsal scale rows and 177-188 ventral scales. They differ from *P. korros* specimens described by Günther (1864) in the number of loreal scales. Günther reported two loreals, but three of the four CUC specimens have only one loreal.



Figure 1. Specimen of *Ptyas korros* from Chittagong University Campus.

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Influence of Temperature on Burrow Use by the Monitor Lizard *Varanus panoptes* of the Coastal Dunes at Fog Bay, Northern Australia

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Abstract.- An increase in the number of *Varanus panoptes* burrows appearing among the sand dunes at Fog Bay in northern Australia was noticed during the dry season (June to August). Entrances of marked burrows were smoothed, and their interiors investigated using a burrowscope, to determine the monthly number of foraging and retreat burrows appearing over a 12 month period. In the dry season, increased numbers of both types of burrows were found. A temperature data logger was used to record temperatures of the sand surface, and at a depth of 50 cm. Burrow depths were measured as how far the burrowscope could be lowered into each burrow. There was a positive correlation between the number of retreat burrows and burrow depths. There was a negative correlation between the number and depth of retreat burrows and the minimum sand-surface temperature and the maximum sand temperature at 50 cm. The number of foraging burrows was independent of sand temperatures. The results indicate a likely thermoregulatory use of retreat burrows with more and deeper burrows prevalent when overnight surface and subterranean sand temperatures decrease.

Key words.- Reptilia, Varanidae, *Varanus panoptes*, Australia, Northern Territory, fossorial, thermoregulation

Introduction

Burrows serve many ecologically important purposes to many animals (Hansell, 1993). Lizards expend less energy throughout the day if a large portion of time is spent in burrows (Bennett and Nagy, 1977). Monitor lizards (*Varanus* spp.) utilise burrows for a variety of purposes such as thermoregulation (Cowles and Bogert, 1944), reducing water loss (Green, 1972), finding prey (Pianka, 1969), and for oviposition and retreat (Cowles and Bogert, 1944; Auffenberg, 1983).

In a recent study of the monitor lizard *Varanus panoptes* (Fig. 1) inhabiting the coastal dunes at Fog Bay, Northern Territory, Australia (12°42'S; 130°20'E), I detected a seasonal change in the number of burrows present. A greater number of burrows appeared among the dunes in June-August (dry season) compared to the rest of the year. These burrows also seemed quite deep compared to those seen in the wet season.

Use of these burrows for oviposition is unlikely since *Varanus panoptes* produces eggs during the wet season. Free access to other water sources might rule out conservation of water loss. Overnight temperatures in the area often drop below 15°C in the dry season. A likely explanation may be that the monitors retreat into burrows at a depth where sand temperatures remain high to conserve overnight body temper-



Figure 1. *Varanus panoptes* in the coastal dunes at Fog Bay, Northern Australia.

ature, as has been found for some other monitors (Cowles and Bogert, 1944; Auffenberg, 1983). The monitors at Fog Bay inhabit the dunes and forage on the beach and dunes (Blamires, 1999). Increased foraging activities may be another explanation for the number of burrows seen in the dry season. The aim of this investigation was to determine whether changes in the number of burrows between the wet and dry

seasons is a result of foraging, thermoregulation, retreat or a combination of these, or other, influences.

Material and Methods

The area of the investigation is approximately 5 km of beach along the northern-most mainland beach at Fog Bay (12°42'S, 130°20'E), approximately 80 km from Darwin, Northern Territory, Australia. The area is privately owned and closed to the public. The sandy dunes are immediately backed by grassland dominated by spinifex vegetation and dispersed *Pandanus* trees. Black soil plains, mangroves and salt flats back the grassland. The dunes of the southern-most 1 km stretch of beach are backed by monsoon forest. The entire 5 km of beach, and the grassland and monsoon forest backing the dunes, was walked twice monthly over a 12 month period.

All burrows encountered were marked with a depth of surveyor's tape tied to nearby vegetation (Fig. 2). To estimate visitation rates the entrances were smoothed and checked, on revisiting, for varanid tracks leading into it.

A small video-camera device, called a "burrow-scope" (Dyer and Hill, 1991; Dyer and Aldworth, 1998) was used to investigate the inside of burrows. The model I used was a modified version of that of Dyer and Aldworth, (1998). A small black and white CCD, 38mm x 38mm, camera (Samsung MOD-BW 204), now popular for home security systems (Capel, 1993) encased in a 375 ml jar was used. Infrared lighting was used to illuminate the burrow for the camera, provided by 10 high intensity light emitting diodes fitted on a piece of Vero board. A small black and white video monitor (260 mm; 5.8 kg) was used for viewing, operated directly from a 12V battery. The wiring from the camera to the monitor was approximately 2 m long and encased in a garden hose. The depth of each burrow was determined by measuring the depth of hose that fed into the burrow to reach its end.

Burrows were assumed to be for foraging when were noted to intersect the burrow of a potential prey item (crab, skink or bird). The number of foraging burrows was totalled each month. Occupied burrows, and those with tracks appearing from the entrance after smoothing, not identified as foraging burrows, were classified as retreat burrows. The number of retreat burrows observed was totalled monthly.

A temperature data logger (model 6003A, Unidata Australia, Perth) was placed on top of one of the dunes with two probes extruding from the logger's case. One of the probes was placed 1 cm below the sand surface, while the other was buried at 50 cm



Figure 2. Burrow of *Varanus panoptes*.

below the surface. A digital temperature reading was taken by the logger every 30 minutes. The data were downloaded and compiled at the end of every month.

Correlation analysis was done between the number of foraging and retreat burrows counted each month and the mean burrow depth. Correlation analysis was also done between the number of foraging burrows, retreat burrows and burrow depths and monthly maximum and minimum sand temperature at the surface and at 50 cm depth.

Results

Overall 93 burrows were identified as either retreat or foraging burrows. Fifty-one were identified as foraging burrows and 42 as retreat burrows, three of the retreat burrows were identified as such because they were occupied by a monitor lizard. The numbers of retreat and foraging burrows observed each month are shown in Figure 3. There was a peak in the number of retreat burrows in July with a steep drop in August and September. The number of foraging burrows observed peaked in April, although the number stays high until July when the number drops. The number of retreat burrows exceeded the number of foraging burrows between May and September.

There was a positive correlation between the number of retreat burrows and the burrow depths recorded each month ($r = 0.67$; $P = 0.017$; Table 1).

Table 1. Correlation coefficients between the number of retreat and foraging burrows and burrow depths.

* denotes a significant correlation

	r	P
Retreat Burrows	0.67	0.017*
Foraging Burrows	0.097	0.763

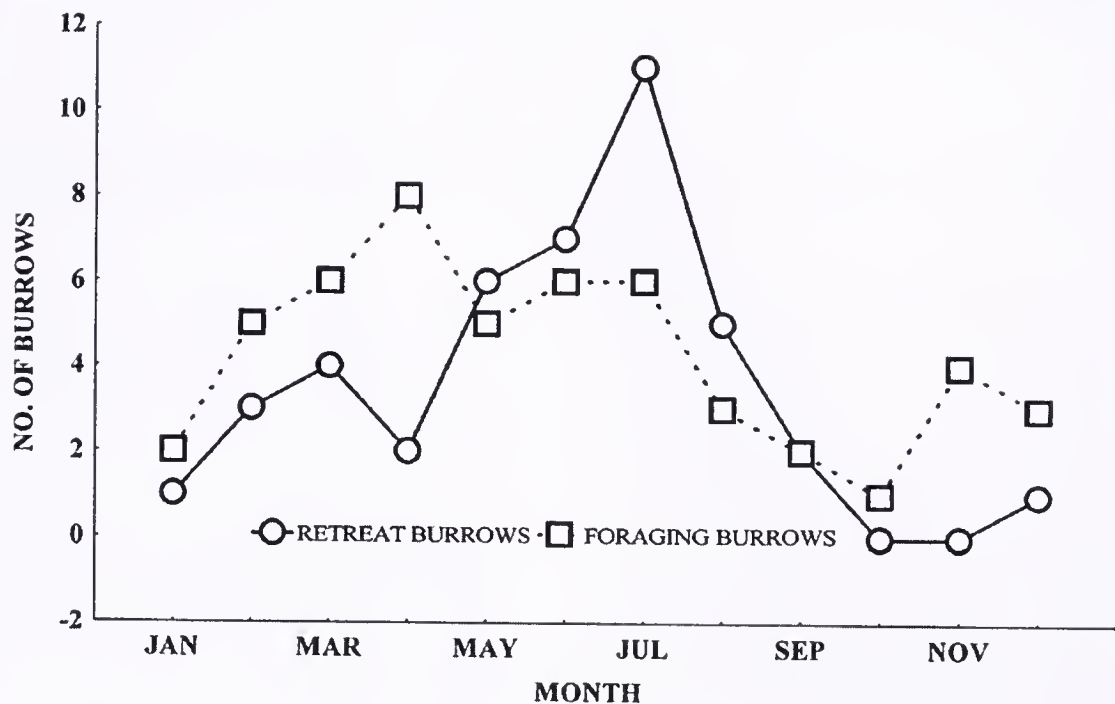


Figure 3. Monthly number of foraging and retreat burrows of *V. panoptes* at Fog Bay.

However, the number of foraging burrows is not correlated to burrow depths (Table 1). The number of retreat burrows are negatively correlated with the minimum sand-surface temperatures ($r = 0.463$; $P = 0.024$) and the maximum sand temperature at 50 cm ($r = -0.616$; $P = 0.033$; Table 2). Burrow depths were also negatively correlated to the minimum sand surface temperature ($r = -0.789$; $P = 0.002$) and the maximum sand temperature at 50 cm ($r = -0.64$; $P = 0.033$; Table 2). The number of foraging burrows was unaffected by sand surface temperature and sand temperature at 50 cm (Table 2). This equates to more and deeper retreat burrows being dug, the cooler the sand temperature at the surface and at 50 cm.

Discussion

The field experiments herein were the first attempt with this modified design of burrow viewing equipment and an assessment of its effectiveness is warranted to justify the results. The only problem encountered was when the original silicon glue (a metal sealant), used to hold the camera to the jar casing, was suspected of having a corrosive effect on the camera. The camera stopped working within a short time and, when inspected, small white spots were seen on the solder of the circuit board. The camera worked properly when the spots were cleaned off and

a non-corrosive sealant (glass/window sealant) was used. From then on, the system provided clear images, with effective viewing of monitor lizard presence in burrows and the depth, width and curvature of all burrows. The narrower, rounder burrows of other animals were easily identifiable at the bottom of foraging burrows.

The number of foraging burrows was independent of depth or temperature influences. However, the greater the number of retreat burrows dug, the greater their depth. The number and depth of retreat burrows was also negatively correlated to minimum sand-surface temperature each month. This is indicative of an increased need for the lizards to burrow to an increasing depth as the overnight temperatures cooled.

Cooler sand temperatures at 50 cm also caused an increase in the number and depth of retreat burrows. Since thermal diffusion in sand is slow, sand temperature at 50 cm heats and cools slowly (Packard and Packard, 1988). The sand temperature at 50 cm at Fog Bay was the highest overnight when the sand surface is lowest (Guinea, 1994). Thus, monitors may be burrowing more in the dry season to exploit the warmer overnight internal sand temperatures. Maximum internal sand temperatures fall during the dry season and the monitors therefore dig further to find even warmer temperatures. Foraging burrows were also responsible for increasing the number of burrows seen in the dry

Table 2. Correlation coefficients between the number of retreat and foraging burrows and burrow depth and sand surface (T_{S0}) minimum and maximum temperatures and sand at 50 cm depth (T_{S50}) minimum and maximum temperatures. * denotes a significant correlation.

	Retreat burrows		Foraging burrows		Burrow depth	
	r	P	r	P	r	P
Min. T_{S0}	-0.643	0.024*	0.18	0.576	-0.789	0.002*
Max. T_{S0}	0.316	0.317	0.227	0.478	0.722	0.008*
Min. T_{S50}	-0.296	0.351	-0.145	0.653	-0.086	0.79
Max. T_{S50}	-0.616	0.033*	0.026	0.937	-0.646	0.033*

season, but their depths were constant, and independent of temperature.

Of other possible reasons for an increase in monitor lizard burrowing in the dry season, egg ovipositing is unlikely, as no eggs were ever observed within burrows and *V. panoptes*. Burrow use to conserve water loss has been proven important for some arid zone monitor lizards (Green, 1972, Vernet et al., 1988). This has not been demonstrated for tropical monitor lizards, although there is a considerable difference in humidity and rainfall between the wet and dry seasons in Australia's wet-dry tropical region (Bureau of Meteorology, 1989). Water loss in lizards increases with decreasing ambient humidity (Hillman and Gorman 1977) and without physiological adaptations to prevent water loss, burrowing to moist sand may be utilised to prevent desiccation by *V. panoptes* when ambient humidity decreases. More needs to be investigated on the water economies, and uses of other water sources, in this monitor to determine if water loss is influential in increasing burrowing during the dry season at Fog Bay.

Acknowledgments

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Notes on the Diet, Survival Rate, and Burrow Specifics of *Uromastix aegyptius microlepis* from the United Arab Emirates

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Abstract.— *Uromastix aegyptius microlepis* are almost exclusively herbivorous and feed on a variety of plant species with *Pennisetum divisum* being extensively utilized in the United Arab Emirates. The survival rate, as determined over a one year period without any rainfall is <50%. Burrow openings are mainly aligned in a southerly and easterly direction with the average burrow entrance size being 60x155 cm. Temperatures measured at 30 cm down the burrow entrance are on average 6°C lower than the ambient temperature.

Key words.— Reptilia, Squamata, Agamidae, *Uromastix aegyptius microlepis*, United Arab Emirates, ecology



Figure 1. The Spiny-tailed lizard, *Uromastix aegyptius microlepis*.

Introduction

Uromastix aegyptius microlepis (Spiny-tail Lizards; Fig. 1) belong to the Family Agamidae and occur throughout the Arabian Peninsula, Iran, Iraq and Jordan (Arnold 1986, Leviton et al. 1992). They are diurnal ground dwelling lizards that may reach sizes of up to 60 cm and are generally yellowish-grey in colour with an impressive spiny club-like tail. Adult *U. a. microlepis* are documented as being mainly herbivorous, although insects form part of their diet, while juvenile lizards are thought to be mainly insectivorous (Arnold 1984, Baha El Din 1996, Brown

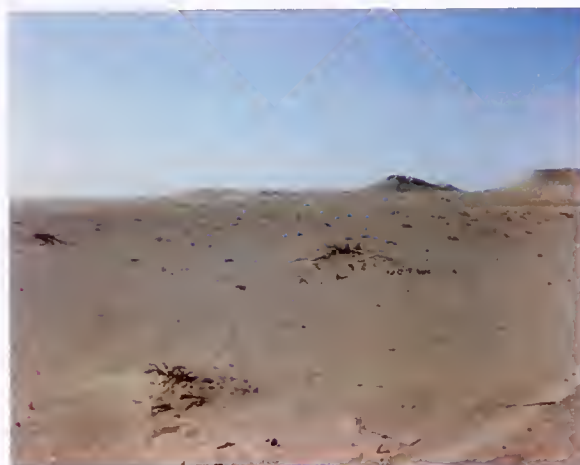


Figure 2. The study site and habitat of *U. a. microlepis* in Abu Dhabi.

1982, Highveld and Slimani 1998, Jongbloed 1997, Manthey and Shuster 1996).

Material and Methods

Twenty mature *Uromastix aegyptius microlepis* individuals in a scattered population, ± 35 km northwest of Al Ain (24°25'07"N and 55°35'01"E; Fig. 2) in the Abu Dhabi Emirate of the United Arab Emirates (UAE), were observed for one full day each (sunrise to sunset). These observations took place during summer (May and June 1999) and winter (December 1999 and January 2000), respectively. I spent 480 observation hours studying these lizards. Direct observations of plant species utilized during their feeding bouts was conducted using an 8x40 binocular over a distance of 100m so as not to influence the feeding behavior. Tracks were also followed once the lizards had retreated underground to confirm sightings. Fecal pellets were collected for later analysis. Burrow

information (orientation, burrow entrance height and width, temperature above ground and 30 cm down burrow) was collected from 25 active burrows once the lizards had retreated.

Survival rate was determined for the 20 study individuals by investigating their burrows for any signs of activity in June 2000, one year after the first observations were made.

Results

Diet. *Uromastyx aegyptius microlepis* utilized the following 10 plant species:

Class Monocotyledonae

Gramineae (Grass family): *Pennisetum divisum*, *Stipagrostis plumosa*

Class Dicotyledonae

Amaranthaceae (Cockscorn family): *Aerva javanica*

Asclepiadaceae (Milkweed family): *Leptadenia pyrotechnica*

Boraginaceae (Borage family): *Moltkiopsis ciliata*, *Heliotropium kotschy*

Chenopodiaceae (Goosefoot family): *Haloxylon salicornicum*

Cucurbitaceae (Gourd family): *Citrullus colocynthis*

Leguminosae (Pea family): *Taverniera cuneifolia*

Polygalaceae (Milkwort family): *Polygala erioptera*

Survival Rate. Of the 20 study individuals first observed in May 1999, only 9 were still present in June 2000.

Table 1. Vegetation selected by *Uromastyx aegyptius microlepis* as documented by different authors from the Arabian Peninsula. * *Pulicaria glutinosa* observed being utilized in other areas although not in the present study area.

This Study UAE – Abu Dhabi	Jongbloed (1997) UAE - Sharjah	Mandeville (1965) Saudi Arabia
<i>Aerva javanica</i>		
		<i>Aristida plumosa</i>
		<i>Astragalus gyzensis</i>
<i>Citrullus colocynthis</i>		<i>Citrullus colocynthis</i>
	<i>Fagonia sp.</i>	
<i>Haloxylon salicornicum</i>		
<i>Heliotropium kotschy</i>		
		<i>Horwoodia dicksonae</i>
		<i>Launaea capitata</i>
<i>Leptadenia pyrotechnica</i>		
<i>Moltkiopsis ciliata</i>		<i>Moltkiopsis ciliata</i>
		<i>Neurada procumbens</i>
<i>Pennisetum divisum capitata</i>	<i>Pennisetum divisum</i>	
		<i>Plantago boissieri</i>
<i>Polygala erioptera</i>		
* <i>Pulicaria glutinosa</i>		
<i>Stipagrostis plumosa</i>		
<i>Taverniera cuneifolia</i>		
	<i>Zygophyllum sp.</i>	

Burrow specifics (n=25). Burrow openings were orientated as follows:

North 2, West 3, South 12 (S/West: 4, South: 5, S/East: 3) and East 8.

Mean average burrow opening height and width was 61 cm and 155 cm (n=25), respectively.

Mean average temperature at a depth of 30 cm down the burrow was 38°C (n=25). The ambient temperature measured at 1.5 m above ground at 13h00 was 44°C.

Discussion

Diet. Ten perennial plant species are selected by *Uromastyx aegyptius microlepis* as observed during the study period, with the coarse desert grasses *Pennisetum divisum* and *Stipagrostis plumosa* being favored. Jongbloed (1997) identified 3 plant species selected by the lizards from the Sharjah area in the UAE while Mandaville (1965) identified 8 plant species from the stomach contents of six *Uromastyx aegyptius* specimens from Saudi Arabia (See Table 1). Foley et al. (1992) identified 23 plant species, mainly annuals, selected by the same species in Israel.

As no rain had fallen during the study period no annuals were observed and therefor the exclusion from the diet. It would therefor be expected that more plant species, especially flowering annuals, would be utilized after rains. Rainfall is highly variable (± 100 mm p.a.) and unpredictable in the UAE (Bottomley 1996) forcing the lizards to rely on the available perennials. According to Zari (1996 and 1998) *Uromastyx philbyi* feed on a variety of annual grasses and perennial shrubs in western Saudi Arabia. Highfield and Slimani (1998) indicate *Uromastyx acanthinurus*'s preference for the family Chenopodia (fat hen/spinach) as well as the salt tolerant *Artiplex* genus and a wide variety of ephemeral plants after rains in Morocco.

An analysis of 170 fresh adult fecal pellets (85 summer and winter, respectively) confirmed the herbivorous nature of *U. a. microlepis* as only one pellet (<1%) contained insect remains, that of a Tenebrionid beetle. According to Highfield and Slimani (1998) adult fecal pellets of *U. acanthinurus* in Morocco contained 6% insect matter. Brown (1982) also mentions *U. a. microlepis* feeding on locusts from the UAE. It still has to be investigated if the lizards

would show a preference for insects during autumn and spring although it is expected that the lack of insects in the diet could be contributed to the fact that most insects, Tenebrionidae at least, are crepuscular or nocturnal (Tiger 1996).

Other items consumed by *Uromastyx* as observed during the fecal analysis of the pellets include: sheep droppings (17 pellets), date kernels (4 pellets) and feathers (3 pellets). It is expected that above mentioned items are consumed erroneously by the lizards as insect material although Brown (1982) suggests that sheep droppings be consumed to extract undigested plant material. If the sheep droppings, date kernels and feathers were consumed as insect material, it would suggest that the lizards would prey on insects more often if they were more readily available.

Survival rate. Nine (45%) of the 20 study individuals survived a period of one year from May 1999 to June 2000. Three of the 11 missing individuals were found as severely malnourished carcasses. The other 8 individuals not accounted for are presumed to have succumbed below ground in their burrows, some of which were covered by sand. No signs of emigration were determined. No rainfall occurred during this period in the study area. The area is also frequented by large numbers of domestic camels and sheep, which compete directly with the lizards for the available food. It is suggested that the lack of rainfall and lack of annual plants as a result of this, together with the extra pressure of domesticated stock, resulted in the high mortality observed.

Burrow specifics. Burrow openings were mainly aligned to the south and east with 80% of the burrow entrances facing this way. During summer, temperatures consistently reach between 40°C and 47°C between 10h00 and 16h00. North and west facing burrow entrances would be hotter than burrows facing in other directions, especially during midday. During winter the lizards would also benefit from the southerly orientation warming the burrows quicker and more effectively. Wind direction during summer is predominantly from the northwest and can cause severe sandstorms locally known as "shamal" (El-Ghonemy 1985). This causes lizard whose burrows face that direction to spend more time on den clearing, a time consuming an energetically costly affair espe-

cially during summer when plant availability and palatability are low.

Burrow size is often related to the size of the resident lizard. The mean average size of 61 x 155 cm (n=25) is indicative of an adult *Uromastix* colony. Bigger burrow openings have higher temperatures at a depth of 30 cm, especially when facing to the north or west.

The mean average temperature of 38°C, during the heat of the day, at a depth of 30 cm down the burrow is on average 6°C lower than the ambient temperature. This gradient is imperative to the survival of the lizards. During the fieldwork it was often found that the lizards were resting in the burrows at a depth of just over 30 cm, scurrying deeper once the thermometer was inserted down the burrow. According to Brown (1982), the burrows can be more than 6 feet long and 3 to 4 feet deep in the form of a spiral. Jongbloed (1997) confirms this depth even indicating reports of up to 12 feet deep burrows. The same author mentions that an excavated burrow of 5 feet in depth was 2 feet across and 1 foot high and still not at its end. Burrows do not only serve as thermoregulatory havens for *Uromastix aegyptius microlepis*, but also for the Desert Monitor (*Varanus griseus*) (Pers.obs.) and certain Larks (Cunningham 2000, Williams et al. 1999). Williams et al. (1999), states that *Uromastix* burrows can potentially reduce Hoopoe Lark (*Alaemon alaudipes*) water loss by as much as 81% during the hottest periods during summer. Temperatures at a depth of 30 cm are relatively stable therefore being exploited by many desert dwelling animals (Lovegrove and Knight-Eloff 1988). Burrows are thus an effective way of escaping predators, the harsh desert environment as well as controlling water loss.

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The Amphibians and Reptiles of Panay Island, Philippines

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Abstract.— We provide species accounts for 20 amphibians (frogs and toads) and 72 reptiles (one turtle, 36 lizards, and 35 snakes) from the central Philippine island of Panay and its associated land-bridge islets. Panay is a moderately-sized island (123,000 km²) that currently is separated from the nearby islands of Negros, Masbate, and Cebu by shallow seas, indicating that dry land connections once allowed free exchange of flora and fauna between these land masses at several periods during the Pleistocene. This fact, coupled with the wealth of knowledge on herpetological communities of Negros and Cebu, has led biologists to assume that the amphibians and reptiles of Panay are reasonably well known. Our data suggest that this is far from true. Our recent survey work (1989 until present) has resulted in the discovery of at least six (and probably 12–15) new species of vertebrates, most of which appear to be high elevation rainforest Panay endemics. In this paper we note numerous taxonomic problems that await the attention of biologists; these surely will result in an increase of the known species from Panay. We expect that many widespread species complexes currently of uncertain taxonomic status will eventually be recognized as Panay endemics, further bolstering the total diversity and degree of endemism on Panay. The status of Panay herpetofauna warrants particular attention because many of the suspected new and endemic species appear to be forest obligates. With the near complete removal of Panay's low elevation forests and increased pressure on its mid- and upper montane forests, we suspect that many of Panay's endemics are threatened by extinction. Panay should be regarded as a tropical island with a unique geological history, a spectacular compliment of habitat types, and a diverse set of species communities – all of which are beset with a conservation crisis of deforestation and probable extinction. Panay may be a particularly appropriate model island for large scale conservation efforts aimed at sustainable management of forest resources. However, before informed conservation and management plans can be enacted, additional biodiversity survey work must be conducted on Panay.

Key words.— Reptiles, amphibians, SE Asia, Philippines, Panay, Visayan Islands, conservation crisis, herpetofauna.

Introduction

The central (or “Visayan”) Philippine island of Panay (Figs. 1, 2), is part of a Pleistocene aggregate island complex that includes Negros, Cebu, Guimaras, Masbate, Ticao, and several small land-bridge islands associated with each of these larger land masses. Although amphibian and reptile species similarity among Visayan Islands was noted much earlier (Taylor, 1920, 1922a–d, 1928; Inger, 1954; Leviton, 1963c; Brown and Alcala, 1970a), it was not until Heaney (1985, 1986) explicitly illustrated the position of the 120 m underwater bathymetric contour in the Philippines that the land bridge implications of channel depth became fully appreciated by biologists. It is

now understood that five major Philippine island groups, (complexes of islands separated by shallow channels) intermittently formed much larger land mass amalgamations at various times during the mid- to late-Pleistocene (Fig. 1). It is presumed that these events allowed free exchange of fauna and flora via land-positive connections between the otherwise isolated islands of today. Each of the Philippine Pleistocene aggregate island platforms (Fig. 1) are now recognized by biogeographers as subprovinces (Taylor, 1928) due to the fact that each supports highly-celebrated suites of endemic taxa (Taylor, 1928; Dickinson, 1991; Heaney and Regalado, 1998; Heaney et al., 1998; Alcala and Brown, 1998; Kennedy et al., 2000).

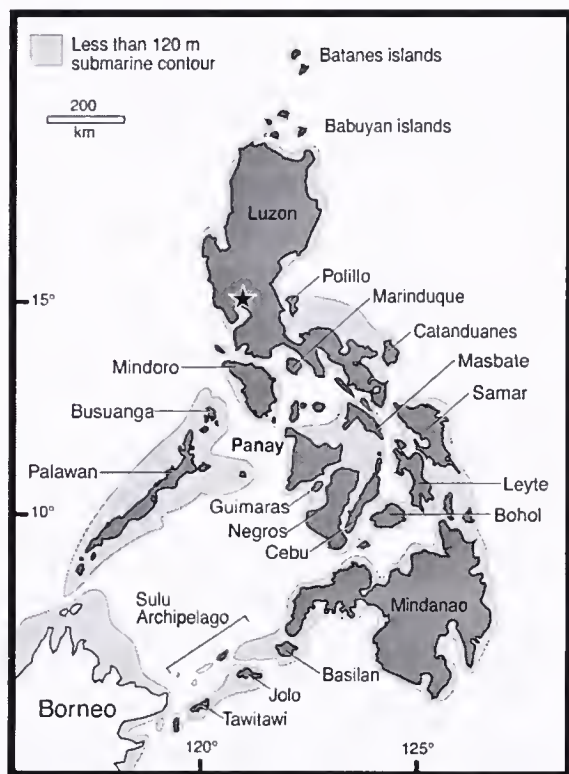


Figure 1. The Philippines (darkly shaded islands), with the major Pleistocene aggregate island platforms indicated by tracing of the 120 m submarine bathymetric contour (following Heaney, 1985, 1986). Star = Manila.

One unfortunate result of the prevailing perspective since Heaney's (1985) landmark paper, has been herpetologists' lack of attention to islands that are land-bridge (once connected by dry land) to well surveyed members of the same Pleistocene island complex. A case in point is Panay, a central Philippine island of 123,000 km² with several mountain peaks of more than 2000 m in elevation (Figs. 1, 2). Perhaps not unreasonably, numerous biologists over the past century have assumed or suggested that a species' presence on the well-surveyed Negros implied its undocumented presence on Panay as well (see Inger, 1954; Leviton, 1963; Brown and Alcala, 1970, 1978, 1980, 1986; Brown and Rabor, 1967; Alcala, 1986). Nevertheless, cases of low-level island endemism have been documented on individual islands within Pleistocene island complexes (Alcala, 1958, 1962; Taylor, 1920; 1922a-d; 1923; 1925; Inger, 1954;

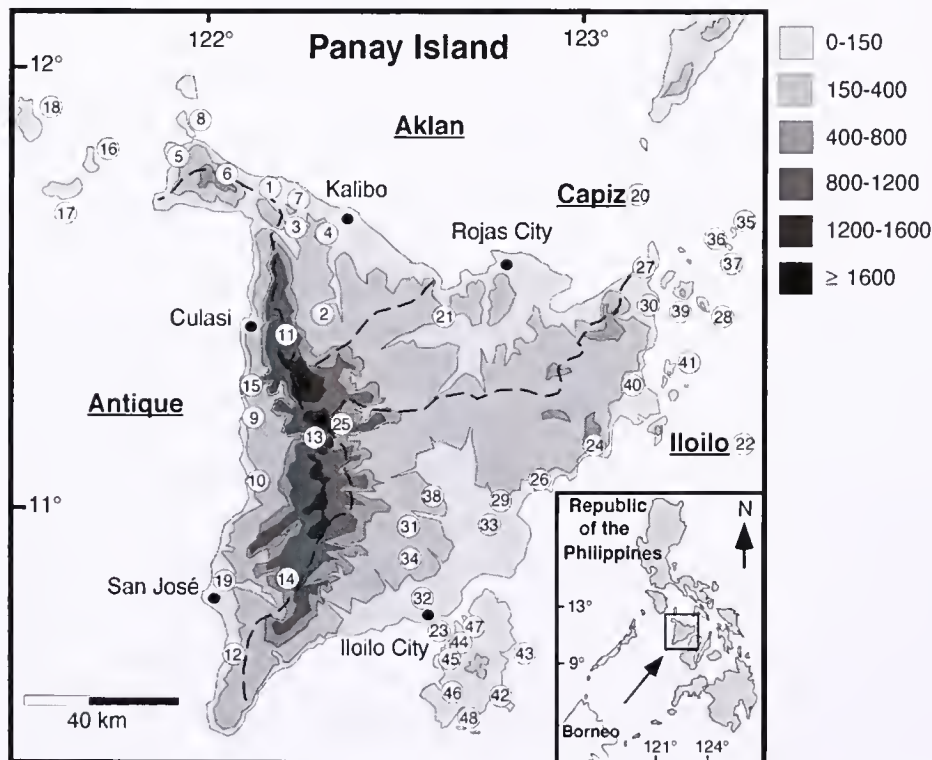


Figure 2. Panay Island, its position in the Philippines indicated by darkened arrow (inset). Discrete shading indicates increasing elevational increments (see key), enclosed numbers indicate collection localities (see Table 1), underlined bold text indicates provinces (boundaries indicated with darkened dashed lines), and darkened circles indicate major cities.

Table 1. Study sites and collection localities for museum specimens of amphibians and reptiles from Panay Island. "No further data available" indicates specimens for which municipalities were the only available collection data in museum catalogs. The term "municipality" is synonymous with "town" but municipalities are also the political entity surrounding towns by these names. Thus, municipalities contain small surrounding villages (Barrios [= "Barangays "] which may contain smaller "Sitios"). It is reasonable to assume that most collections localized to the municipality level were also collected in the town of the same name. Entries including "and vicinity" indicates specimens that may have been collected in the municipal town, or they may be from smaller surrounding Barangays. * Combined into a single locality due to the close proximity of collection sites at the common borders of these municipalities.

Site	Province	Municipality	Notes
1.	Aklan	Ibajay	Barangay Bugtong-bato
2.	Aklan	Libacao	Libacao town "and vicinity"
3.	Aklan	Makato	Makato town "and vicinity"
4.	Aklan	Malinao	no specific locality data
5.	Aklan	Malay	Nogas Point
6.	Aklan	Nabas	Nabas town "and vicinity"
7.	Aklan	Tangalan	Tangalan town "and vicinity"
8.	Aklan	Malay	Borocay Isl., no specific locality data
9.	Antique	Barbaza	Barbaza town "and vicinity"
10.	Antique	Bugasong	Bugasong town "and vicinity"
11.	Antique	Culasi	Barangay Alojipan (Mt. Madja-as; PNM/CMNH site)
12.	Antique	Tobias Fornier	Barangay Tobias, Villaflor
13.	Antique	Valderrama	Barangay San Agustin, (Mt. Baloy and vicinity; PNM/CMNH site)
14.	Antique	San Remegio	Barangay Aningalan, Aningalan mountain range
15.	Antique	Tibiao	no specific locality data
16.	Antique	Caluya	Caluya Isl., no specific locality data
17.	Antique	Sibay	Sibay Isl., no specific locality data
18.	Antique	Caluya	Semirara Isl., no specific locality data
19.*	Antique	Hamtik	Barangay Gunisang-an
		Sibalom	Barangay Egaña
		San José	Barangay Bagumbayan
20.	Capiz	Capiz	no specific locality data
21.	Capiz	Marubusao	Burias
22.	Iloilo	Iloilo	no specific locality data
23.	Iloilo	Iloilo City	Iloilo City "and vicinity"
24.	Iloilo	Ajuy	no specific locality data
25.	Iloilo	Calinog	Mt. Baloy and vicinity

Site	Province	Municipality	Notes
26.	Iloilo	Barotac Viejo	Barangay San Francisco
27.	Iloilo	Carles	no specific locality data
28.	Iloilo	Carles	Sicogon Island; including Buaya area
29.	Iloilo	Dingle	Bulabog-Putian National Park; PNM/ CMNH Site
30.	Iloilo	Estancia	no specific locality data
31.	Iloilo	Lambunao	no specific locality data
32.	Iloilo	Mandurriao	no specific locality data
33.	Iloilo	Pototan	Pototan town "and vicinity"
34.	Iloilo	Cabatuan	no specific locality data
35.	Iloilo	Estancia	Gigante North Isl., no specific locality data
36.	Iloilo	Estancia	Gigante South Isl., Gabi area
37.	Iloilo	Estancia	Gigante South Isl., no specific locality data
38.	Iloilo	Calinog	E. Catalbac ("Calinog town")
39.	Iloilo	Estancia	Calagna-an Isl.; Barangkalan and vicinity
40.	Iloilo	Concepcion	ca 1 km NW SBS Iyang Beach Resort
41.	Iloilo	Concepcion	Pan de Azucar Isl., no specific locality data
42.	Negros Occidental	Pulupandan	Inampulagan Isl., 8 km W Munic. W. Pulupandan, Negros Occ. Prov.
43.	Iloilo, Subprov. Guimaras	Unknown	Guimaras Isl., no specific locality data
44.	Iloilo, Subprov. Guimaras	Jordan	Guimaras Isl.; Jordan town "and vicinity"
45.	Iloilo, Subprov. Guimaras	Unknown	Guimaras Isl.; 2.1 km SW Daan Banwa
46.	Iloilo, Subprov. Guimaras	Nueva Valencia	Guimaras Isl.; Nueva Valencia town "and vicinity"
47.	Iloilo, Subprov. Guimaras	Buenavista	Guimaras Isl.; Buenavista town
48.	Iloilo, Subprov. Guimaras	Nueva Valencia	Panobolon Isl.; Nueva Valencia town.
49.	Unknown	Unknown	"Masaya" (not on available maps)
50.	Unknown	Unknown	Panay Island: no Further Data

Brown and Alcala, 1961, 1970a–b, 1978, 1980, 1982a, 1986, 1994; Brown et al., 1997a–b; Brown et al., 1999), suggesting that the two large islands warrant individual attention by biogeographers. Despite the assumption that many widespread Philippine species were present on Panay (e.g., see Alcala, 1986), biogeographical summaries and taxonomic reviews historically have listed only nine vouchered (based on museum specimens) species of snakes, six geckos, six skinks, and seven frogs (Inger, 1954; Leviton, 1963c; Brown and Alcala, 1970, 1978, 1980) – 30% of the herpetofauna considered in the present report.

Until very recently the higher elevation forested regions of Panay have not been explored by biologists. At present, the results of only a few preliminary surveys in a few high elevations localities are available (Gonzales and Kennedy, 1990, 1996; Sison et al., 1995; Ferner et al., 1997; Brown et al., 1997a; 1999).

The purpose of this paper is to synthesize museum records that document the diversity, endemism, status, and distribution of the amphibians and reptiles from Panay and to report on several recent collections resulting from the National Museum of the Philippines/Cincinnati Museum of Natural History Philippine Biodiversity Inventory (1989–1994). Another primary goal is to draw attention to recently-discovered endemic species of amphibians and reptiles from Panay and to stress the need for immediate faunal surveys on this tropical island beset by a conservation crisis of deforestation.

Material and Methods

Study sites and collection locations are presented in Table 1 and shown in Figure 2. Additional site and habitat information for many TNHC, PNM, CAS, FMNH, and CMNH specimens may be found in the museum catalogs. The PNM/CMNH Philippine Biodiversity Inventory team conducted field studies at sites 11 and 13 (Figs. 3–9) and various members of the team (particularly RVS and RMB), visited other locations (Figs. 10–14) to do more limited surveying. We established elevational transects in a variety of habitat types (Ruedas et al., 1994, as modified by Brown et al. 1995a, 1996, 2000) and utilized standard collection and specimen preservation techniques (Simmons, 1987; Heyer et al., 1994). Detailed examination of all material was conducted by RMB and JWF.

We follow the taxonomy of Taylor (1922c), Brown and Alcala (1978, 1980) and Brown et al. (1995a; 1995b) for gekkonid and scincid lizards. The taxonomy of Inger (1954, 1996), Frost (1985), Duellman

(1993), Brown and Alcala (1994), Inger and Tan (1996), Alcala and Brown (1998) and Emerson et al. (2000), was consulted for amphibians and we include (in parentheses) the unsubstantiated taxonomic hypotheses of Dubois (1992) for reference. While no suitable taxonomy currently is available for Philippine agamids (see Taylor, 1922c), we consulted Musters (1983) and McGuire and Alcala (2000) for identification of our *Draco* specimens. Snake taxonomy was based on Taylor (1922a), Leviton's "Contribution to a Review of Philippine Snakes" series (Leviton 1961, 1962, 1963a–c, 1964a–d, 1965, 1967, 1968, 1970a–b, 1979, 1983, 1985), Leviton and Brown (1959), Inger and Marx (1965), Malnate and Underwood (1988), Wynn and Leviton (1993), McDiarmid et al. (1999), and Brown et al. (1999). Scale counts on snakes were taken using the methods of Dowling (1951a, 1951b). Field techniques in our surveys have been described in Ruedas et al. (1994) and Brown et al. (1995a; 1996; 2000). Museum abbreviations follow Duellman et al. (1978) and Leviton et al. (1985).

In order to examine large scale faunal similarities between Panay and other large island of the Philippines, we assessed overall herpetofaunal similarities by calculating coefficients of similarity using a simple index ($C = 2W/a+b$; see Brown and Lomolino, 1998, for review) for the amphibians and reptiles of Panay and other islands. Our data for these calculations were based on all available literature (above) and updated conservative estimates of the taxonomy of Philippine amphibians and reptiles (Brown, Crombie, Diesmos, unpublished data).

Results

We present records for 20 amphibians (anurans; Figs. 15–25), and 72 reptiles (one turtle, 36 lizards, and 35 snakes; Figs. 26–52) from Panay and its associated land-bridge islets. The results of faunal similarity calculations are presented in Figure 53. Individual species accounts, with comments on their status, are presented below.

Species Accounts

Amphibia

Anura

Bufonidae

Bufo marinus (Linnaeus) (Fig. 15)

Introduced on most inhabited islands of the Philippines (Inger, 1954; Diesmos, 1998; Alcala and Brown, 1998), this species is particularly common in agricultural areas and near human habitation. It is widespread and abundant in disturbed and agricultural areas on Panay.

Localities and specimens: (Site 1) PNM 1144–47, 1228–33; (Site 11) CMNH 4958–59, PNM 1289–96, 2552–54; (Site 12) PNM 1232–33; (Site 19) CMNH 5197; (Site 23) USNM 339985–86; (Site 24) FMNH 61482–84; (Site 31) PNM 1144–47; (Site 33) USNM 339987–88, 340062.

Microhylidae

Kaloula conjuncta negrosensis Taylor (Fig. 16)

Taylor (1920, 1922a) first collected this form on Negros and Guimaras islands. He (Taylor, 1922a) recognized it as a full species but Inger (1954) placed *K. negrosensis* in the synonymy of Luzon's *Kaloula conjuncta*; no further taxonomic studies have been forthcoming. *Kaloula conjuncta negrosensis* is both a burrower and a climber (Taylor, 1920; Alcala, 1962, 1986); it has been found in the detritus of the forest floor (750–1075 m on Negros; Alcala, 1962) and in the leaf axils and holes of trees (Alcala 1962). They also emerge and congregate around water that collects in pools and ditches in the rainy season (Taylor, 1920, 1922a). Our Mt. Madja-as specimen was found in a tree hole 10 cm from the ground (tree < 0.5 m dbh). Specimens from near the base of Mt. Baloy were found in breeding aggregations around water buffalo wallows near a large river. We suspect that the Visayan populations represent a distinct evolutionary lineage and that they will eventually once again be recognized as a full species once new data become available (Brown and Diesmos, unpublished data).

Localities and specimens: (Site 8) CAS 127890; (Site 11) PNM 2555; (Site 13) TNHC 56340–46; (Site 16) CAS 127510–11, 127591; (Site 18) CAS 127815; (Site 47) CAS 124446.

Kaloula picta (Dumeril and Bibron) (Fig. 17)

This frog is found at low elevations (100–200 m) in open areas near human habitations (Boulenger, 1882; Alcala, 1956, 1958). It is a burrowing species that conceals itself under leaf litter and topsoil until the beginning of the rainy season. Choruses may contain hundreds of individuals (Alcala, 1962; Alcala and Brown, 1998). This appears to be the first published account of this species on Panay.

Localities and specimens: (Site 16) CAS 127617–37; (Site 18) CAS 127816, 127827; (Site 23) CAS–SU 14219–20; USNM 78079–80, 78842.

Kaloula sp.

In 1992, while conducting survey work at Barangay Alojipan (Site 11), we heard the distinctive honking calls of a forest species of *Kaloula*. Although we were unable to locate and collect specimens, we noted that the calls were superficially similar to *Kaloula kalingensis* (Taylor, 1922a; single honk, delivered approximately every 15 to 20 minutes) from Luzon. Neither *Kaloula kalingensis* nor the related *K. kokacii* (Ross and Gonzales, 1991) have been reported from the nearby island of Visayas, although recent field work in the last remaining low elevation forests of Negros (Municipality of Ayungon, Negros Oriental Prov.; C. N. Dolino and A. C. Diesmos, personal communication) reveals the presence of a forest species (also previously unrecorded) with single honking calls there as well. Gaulke (in press) recently has discovered a population of *Kaloula* in NW Panay that may be the same as that heard (but not collected) previously on Panay and Negros.

Localities and specimens: none.

Ranidae

Limnonectes cf. *leytensis* (Boettger) (Fig. 18)

This species is widely distributed in patches and considered common in some localities on the nearby Negros (Alcala, 1986; Alcala and Brown, 1998). However, it has been collected from only one locality on Panay (Sison et al., 1995). On Negros, this species inhabits cool high elevation mountain streams between 150 and 900 m (Alcala, 1962) and probably breeds terrestrially but deposits eggs in close proximity of water (Alcala and Brown, 1956; Alcala, 1962; Brown and Alcala, 1982b). When hatching, terrestrial embryos of these and related species fall, are carried by males, or are washed into water (Alcala, 1962; see also Inger et al., 1986; Brown and Iskandar, 2000). We find it doubtful that Visayan specimens identified

Table 2. List of known species from Panay and smaller, nearby, land-bridge islands and other islands within the political boundaries of major Panay Island provinces. Entries include Panay species with vouchered specimens in major museum collections (see text and species accounts for discussion of taxonomy used) and the first published accounts by authorities utilizing museum specimens. IR = island record or first published record from within major Panay island provinces. (1 Previously reported from Panay, nearby islets, or Visayan sea by Alcala (1986) but without specific reference to specimens. 2 See also Gaulke (in press). 3 Recorded from land-bridge islets but currently not recorded from the mainland of Panay. 4 A record from Semirara Isl., within the political boundary of Panay's Antique Province, but land-bridge to Mindoro Isl.; not likely to be discovered on Panay in the future. 5 Apparent major range extension, in need of verification or based on specimens with locality data probably in error.)

<i>Bufo marinus</i>	Inger, 1954
<i>Kaloula conjuncta negrosensis</i>	IR (see Taylor, 1920; 1922a) ¹
<i>Kaloula picta</i>	IR
<i>Kaloula</i> sp.	IR ²
<i>Limnonectes</i> cf. <i>leytensis</i>	IR
<i>Limnonectes visayanus</i>	Inger, 1954
<i>Occidozyga laevis</i>	Inger, 1954
<i>Platymantis corrugatus</i>	IR ²
<i>Platymantis dorsalis</i>	IR ²
<i>Platymantis negrosensis</i>	Sison et al., 1995
<i>Platymantis insulatus</i>	Brown and Alcala, 1970b ³
<i>Platymantis panayensis</i>	Taylor, 1920; Inger, 1954; Brown et al., 1997a
<i>Platymantis</i> sp. 1	IR
<i>Platymantis</i> sp. 2	IR
<i>Platymantis</i> sp. 3	IR
<i>Rana cancrivora cancrivora</i>	Inger, 1954
<i>Rana erythraea</i>	Inger, 1954
<i>Rana</i> cf. <i>everetti</i>	Sison et al., 1995
<i>Rana vittigera</i>	IR
<i>Polypedates leucomystax</i>	Inger, 1954
<i>Cuora amboinensis amboinensis</i>	Gaulke and Fritz, 1998
<i>Bronchocela</i> sp.	Taylor, 1922c
<i>Draco spilopterus</i>	Musters, 1983
<i>Hydrosaurus pustulatus</i>	IR ²
<i>Gonocephalus</i> sp.	Sison et al., 1995
<i>Cosymbotus platyurus</i>	Brown and Alcala, 1978
<i>Cyrtodactylus annulatus</i>	IR ²

<i>Cyrtodactylus philippinicus</i>	IR
<i>Gehyra mutilata</i>	Brown and Alcala, 1978
<i>Gekko gecko</i>	Taylor, 1922c; Brown and Alcala, 1978
<i>Gekko gigante</i>	Brown and Alcala, 1978 ³
<i>Gekko mindorensis</i>	Sison et al., 1995
<i>Hemidactylus frenatus</i>	Brown and Alcala, 1978
<i>Hemidactylus stejnegeri</i>	Sison et al., 1995
<i>Hemiphyllodactylus insularis</i>	Brown and Alcala, 1978
<i>Lepidodactylus lugubris</i>	Brown and Alcala, 1978 ³
<i>Lepidodactylus planicaudus</i>	Brown and Alcala, 1978
<i>Brachymeles boulengeri taylori</i>	IR
<i>Brachymeles talinis</i>	Brown and Alcala, 1980
<i>Brachymeles tridactylus</i>	Brown and Alcala, 1980
<i>Dasia grisea</i>	Brown and Alcala, 1980 ⁴
<i>Dasia semicineta</i>	IR ⁵
<i>Emoia atrocostata</i>	IR ³
<i>Lamprolepis smaragdina philippinica</i>	Brown and Alcala, 1980
<i>Lipinia pulchella taylori</i>	IR
<i>Mabuya indepressa</i>	Sison et al., 1995
<i>Mabuya multicarinata borealis</i>	IR
<i>Mabuya multifasciata</i>	IR ²
<i>Parvoscincus sisoni</i>	Ferner et al., 1997
<i>Sphenomorphus arborens</i>	Brown and Alcala, 1980
<i>Sphenomorphus coxi divergens</i>	IR ⁵
<i>Sphenomorphus cumingi</i>	IR ⁵
<i>Sphenomorphus jagori grandis</i>	Brown and Alcala, 1980
<i>Sphenomorphus steerei</i>	Brown and Alcala, 1980
<i>Tropidophorus grayi</i>	Sison et al., 1995
<i>Varanus salvator nuchalis</i>	Gaulke, 1991a, 1991b, 1992
<i>Acrochordus granulatus</i>	IR
<i>Python reticulatus</i>	Leviton, 1963c
<i>Ahaetulla prasina preocularis</i>	Leviton, 1963c, 1968
<i>Boiga angulata</i>	IR ²

<i>Boiga cf. cynodon</i>	IR ²
<i>Boiga cf. dendrophila</i>	IR
<i>Calamaria gervaisi</i>	Leviton, 1963c; Inger and Marx, 1965
<i>Cerberus rynchops</i>	Gyi, 1970
<i>Chrysopelea paradisi</i>	Sison et al., 1995
<i>Cyclocorus lineatus alcalai</i>	IR
<i>Dendrelaphis caudolineatus terrificus</i>	Leviton, 1970b
<i>Dendrelaphis pictus pictus</i>	Leviton, 1963c, 1970b
<i>Elaphe erythrura psephenoura</i>	Leviton, 1979
<i>Gonyosoma oxycephala</i>	IR ²
<i>Hologerrhum dermali</i>	IR ²
<i>Lycodon aulicus capucinus</i>	Leviton, 1965
<i>Oligodon modestum</i>	Sison et al., 1995
<i>Psammodynastes pulverulentus</i>	IR ²
<i>Pseudorabdion mcnamarae</i>	Sison et al., 1995
<i>Pseudorabdion oxycephalum</i>	IR
<i>Pseudorabdion talonuran</i>	Brown et al., 1999
<i>Tropidonophis negrosensis</i>	Leviton, 1963c; Malnate and Underwood, 1988
<i>Zaocys luzonensis</i>	Ross et al., 1987
<i>Calliophis calligaster gemianulus</i>	Leviton 1963b, 1963c
<i>Hydrophis belcheri</i>	IR ¹
<i>Hydrophis cyanocinctus</i>	IR ¹
<i>Hydrophis elegans</i>	IR
<i>Hydrophis inornatus</i>	IR
<i>Lapemis hardwickii</i>	IR ¹
<i>Laticauda colubrina</i>	IR
<i>Ramphotyphlops braminus</i>	IR
<i>Rhamphotyphlops cumingii</i>	IR
<i>Typhlops castanotus</i>	Wynn and Leviton, 1993
<i>Typhlops hypogius</i> (= <i>T. ruber</i> ?)	IR? (see McDiarmid et al., 1999)
<i>Tropidolaemus cf. wagleri</i>	IR
<i>Trimeresurus flavomaculatus</i>	Gaulke (in press)

as *Rana cf. leytensis* are conspecific with specimens referred to this species from the Mindanao Aggregate Island Complex (Leyte, Samar, Bohol, and Mindanao).

Locality and specimens: . (Site 25) PNM 1114–15.

***Limnonectes visayanus* (Inger) (Fig. 19)**

This large fanged frog is found in clear forest streams; it is known to hide in rock crevices during the day and call from rocks and stream banks above water at night (Alcala, 1962; Alcala and Brown, 1998). We found *L. visayanus* at low elevations on rocks in large rivers near Mt. Madja-as. This species may breed and lay eggs outside of water (Alcala, 1962).

Localities and specimens: (Site 2) PNM 1715–20; (Site 3) CAS 137592–95, 137590–91, 139164–66, USNM 305671–76; (Site 4) PNM 1613–20, 1623–27; (Site 6) CAS 137596–98; (Site 7) PNM 1799–800, 1828–31, 1836–39, 1845, 1855–60, 1865–77; (Site 11) CMNH 4894–98, 4899, PNM 1302–06, 2617–21; (Site 13) TNHC 56337; (Site 14) PNM 3710–12, 3732, 3764–68, 3805; (Site 25) 1085–92, 1133–38, 1140; (Site 28) CAS 124093–106, 124442–44, 124950–58; (Site 39) CAS 124121, 124293–97; (Site 44) CAS 125308–309, 125312; (Site 47) CAS 125302–307; (Site 50) USNM 78072–78.

***Occidozyga laevis* (Günther) (Fig. 20)**

Occidozyga laevis is found in flooded fields in agricultural areas, in road-side ditches and open sewers, and in streams and rivers from lowlands to high elevation forested sites (Inger, 1954; Alcala, 1962; *pers. obs.*). On Negros this species has an altitudinal range of sea level to 1150 m (Alcala, 1962). Specimens are common in stream-side pools along larger rivers in forested areas near Mt. Madja-as and Mt. Baloy.

Localities and specimens: . (Site 1) PNM 1110–11, 1113, 1116–29, 1141, 1184–99; (Site 2) PNM 1116–29, 1690–1714, 1721–23, 1731, 1757–58; (Site 3) CAS 137586–88, 139148, 139167–68, USNM 305647–48; (Site 4) PNM 1600–02, 1611, 1621–22; (Site 6) CAS 137614–15, USNM 305649, 305650–54; (Site 7) PNM 1832–35, 1841–44, 1848–54, 1862–64, 1880; (Site 9) PNM 1156, 1165–68, 1170–71; (Site 10) PNM 1110–11, 1113; (Site 11) CMNH 4951–57, PNM 1329, 2655–61; (Site 12) PNM 1163–64; (Site 14) PNM 3730–31, 3782, 3804; (Site 22) CAS–SU 9813; (Site 23) CAS–SU 14224–25, 14373; (Site 24) FMNH 61478–81; (Site 25) PNM 1141; (Site 26) PNM 1160–62; (Site 27) CAS–SU 14049; (Site 28) CAS 124959–70, 124059–76, 124426, 124432–33, 124439; (Site 30) CAS–SU 14223; (Site

32) PNM 1172–73; (Site 38) CAS 132880, 132887–901, 134089–96; (Site 39) CAS 124171, 124190–91; (Site 40) USNM 339989; (Site 41) CAS 125001, 124177, 124184–85, 124194–96; (Site 42) CAS–SU 23946–49, 23952–58, 23961–63; (Site 44) CAS 125361–62; (Site 47) CAS 125311, 125344–59.

***Platymantis corrugatus* (Dumeril) (Fig. 21)**

This widely distributed terrestrial frog inhabits the forest floor from sea level to above 1300 m (Alcala, 1986). On Mt. Madja-as we found *P. corrugatus* in leaf litter and in limestone crevices. This account and that of Gaulke (in press) appear to be the first published records of this species from Panay.

Localities and specimens: (Site 6) CAS 137616–19, 139149, 185494; (Site 11) CMNH 4960–63, 5118, PNM 2556–59; (Site 13) CMNH 3160–65; (Site 25) PNM 1103–06; (Site 28) CAS 124058.

***Platymantis dorsalis* (Dumeril)**

This common forest frog is found in the detritus of the forest floor as well as in tree cavities and low tree ferns (Alcala, 1962; Alcala and Brown, 1998). Although recent studies (Brown et al., 1999) indicate the presence of numerous cryptic species in the *P. dorsalis* complex on Luzon (and we suspect that further new species await discovery in the Visayan islands), the calls of some *P. dorsalis* have been heard on Mt. Baloy and Mt. Madja-as are, at least superficially, similar to the short, whistling, ascending frequency sweep of true *P. dorsalis* from Luzon Island (Brown et al., 1997c). Thus, while we expect that more species in the *dorsalis* complex will soon be discovered in the Visayas, we can confidently assert that at least some Panay populations are indistinguishable from *P. dorsalis* of Luzon Island (Brown et al., 1997c; 1999). This account and that of Gaulke (in press) appear to be the first published records of this species from Panay.

Localities and specimens: . (Site 2) PNM 1734–56; (Site 6) CAS 137620–40, 137649–51, 139150–63, USNM 305655–70; (Site 11) CMNH 4964–98, 5206, PNM 2559, 2562–88; (Site 13) TNHC 56347–50; (Site 14) PNM 3713–19, 3729, 3733–45, 3756–62, 3772–74, 3783–85, 3788–89, 3791–96, 3830–31, 3857, 3860, 3862–65, 3882–83, 3886–88, 3893–95, 3906–08; (Site 25) PNM 1093–102; (Site 28) CAS 124419, 124428–31, 124440–41, 124689–91; (Site 39) CAS 124123–33, 124146–47; (Site 41) CAS 124041–42, 124122, 124186–89, 125014–19.

***Platymantis negrosensis* Brown, Alcala, Alcala, and Diesmos**

This recently-described forest frog (Brown et al., 1997b) has only been documented from two sites on Panay but is also known from localities on the nearby island of Negros, from approximately 300 to 1625 m in elevation (Alcala, 1958; Alcala and Brown, 1957; Alcala, 1962). On that island, this species occupies arboreal microhabitats in primary forest (Brown and Alcala, 1961; Alcala, 1962; Brown et al., 1997b). We documented this island record for Panay (Sison et al., 1995; then recognized as *P. guentheri*) from specimens collected in forest on Mt. Baloy at about 950 m. This species is related to *P. luzonensis* but differs in characteristics of the advertisement call and external morphology (Alcala and Brown, 1998).

Localities and specimens: . (Site 13) CMNH 3166; (Site 14) PNM 3889.

***Platymantis insulatus* Brown and Alcala (Fig. 22)**

A frog known from primary and secondary forest situated on karst limestone outcrops, this species was originally discovered (Brown and Alcala 1970b) on the forest floor and in the open mouths of small caves at low elevations (Alcala and Brown, 1998) on the island of Gigante South off Panay's northeast coast. A recent (June 2000) visit to the type locality by R. Brown and A. Alcala confirmed this species' persistence despite the complete removal of the original forest. The presence of an endemic species on such a small, land-bridge island is puzzling and suggests that it may still be (or at least, may have once been) present on eastern Panay. Unsurveyed limestone formations along the northeastern coast are the most promising possibility for locating this species on Panay.

Localities and specimens: . (Site 35) CAS 157235–39; (Site 36) CAS 137641–42; (Site 37) CAS 117440–41; 119967–69, MCZA-72946.

***Platymantis panayensis* Brown, Brown and Alcala**

Only recently described (Brown et al., 1997a) from our collections from Mt. Madja-as, this species is closely related to *P. hazelae* from Negros and occupies similar microhabitats in high elevation cloud forests. Taylor (1920:101) apparently had a specimen (collected by R. McGregor) of this species on hand during the description of *Philautus* (= *Platymantis*) *hazelae* and he considered it conspecific with the Negros population. On the basis of Taylor's (1920)

account, Inger also (1954) included *P. hazelae* in his list of species from Panay.

We collected the majority of the type specimens of this species from leaf axils, leaves on shrubs, and the leaf litter on the forest floor. The call has not yet been formally described, but consists of a pure, ringing, tonal note with no frequency or amplitude modulation; it sounds to the human ear like the sound produced by the ringing of a small bell (1–2 notes/s).

Localities and specimens: (Site 6) CAS 137641–42; (Site 11) PNM 2314–18, 2495, 2589–90; CMNH 4113–15, 4116–20, 4868–69.

***Platymantis* sp. 1**

Several immature specimens of a tiny, dark brown, tuberculate (11–15 mm SVL) species of *Platymantis* were taken at high elevations on Mt. Madja-as and on Mt. Baloy. They appear most similar to *Platymantis pygmaeus* of the Sierra Madre mountains of Luzon's east coast. Due to the fact that the available specimens are all sexually immature, we cannot recognize them taxonomically until further material and recordings of advertisement calls become available.

Localities and specimens: (Site 11) CMNH 8132 (Site 13) CMNH 3173–74, 3177.

***Platymantis* sp. 2**

Two immature specimens of a diminutive, black, smooth-skinned (12–13 mm SVL) species of *Platymantis* were collected at 1450 m from under leaf litter. The small sample size and immaturity of the specimens necessitates that taxonomic recognition of the species must await the collection of further material.

Locality and specimens: (Site 11) CMNH 8133–34.

***Platymantis* sp. 3**

This unidentified species is represented by a single, very large, black specimen with two dorsolateral light lines; it appears possibly related to *P. pseudodorsalis* from Luzon (Brown et al., 1999).

Locality and specimen: (Site 6) CAS 185495.

***Rana* (= "*Fejervarya*") *cancrivora cancrivora* Gravenhorst**

This common frog is found in swamps, ponds, flooded rice fields and ditches (Inger, 1954). It is found in almost any pool of water at low elevations (Alcala and Brown, 1998). Inger (1954) first reported it on Panay Island.

Localities and specimens: . (Site 1) PNM 1178–82; (Site 8) CAS 127893–95, 127899–904; (Site 9) PNM

1156; (Site 16) CAS 127509, 127559–81, 127611, 127678–79; (Site 17) CAS 127800; (Site 18) CAS 127801–803; (Site 19) PNM 2607–16; (Site 22) USNM 78862–902; (Site 23) CAS–SU 14259–60, 14452–79, 15486–514, USNM 77984–96, 77988–78042, 78048, 78062–65; (Site 24) FMNH 61398–402; (Site 26) PNM 1160–62; (Site 27) CAS–SU 14513–25; (Site 28) CAS 124262–71, 185665–69; (Site 30) CAS–SU 14252–57; (Site 34) CAS–SU 9762–63; (Site 36) CAS 124343; (Site 37) CAS 124564–76; (Site 38) CAS 132878–79; (Site 39) CAS 124135, 124175; (Site 40) USNM 339990, 340059–60; (Site 41) CAS 124178–79, 124320–28, 125020–28; (Site 42) CAS–SU 23966; (Site 44) CAS 125194–96; (Site 46) CAS 125183–93; (Site 47) CAS 125174–82; (Site 48) CAS 124791–92; (Site 50) USNM 78066–71.

***Rana* (= "*Hylarana*") *erythraea* (Schlegel) (Fig. 23)**

This widely-distributed and common frog is believed to have been introduced to the Philippines (Diesmos, 1998; Alcalá and Brown, 1998), originally on Negros (Inger, 1954; Alcalá, 1962; Alcalá and Brown, 1998). Its presence on Panay has been previously documented (Taylor, 1920; Inger, 1954). We found our specimens along the grassy borders of flooded rice fields.

Localities and specimens: (Site 2) PNM 1725–26; (Site 3) CAS 137589; (Site 4) PNM 1603–10, 1612; (Site 7) PNM 1840; (Site 8) CAS 127891–92, 127905–912; (Site 10) PNM 1174–76; (Site 11) CMNH 4870, PNM 1309–28, 2591–92; (Site 14) PNM 3816; (Site 19) PNM 2622–54; (Site 22) CAS–SU 9744; (Site 23) CAS–SU 14537–47, USNM 77730–983, 78043–47, 78049–61; (Site 24) FMNH 61391–97, 61449–52; (Site 27) CAS–SU 14578–84; (Site 30) CAS–SU 11120–24, 14526–36, FMNH 40527; (Site 33) USNM 38650–54; (Site 38) CAS 132881–86, 134086–88; (Site 39) CAS 124209–212, 124214; (Site 44) CAS 125158–69; (Site 47) CAS 124143–57, 125310; (Site 50) USNM 77617–729, 78413–38.

***Rana* (= "*Chalcorana*") cf. *everetti* Boulenger**

Species of the *Rana everetti* complex are found in and along streams from 300 to about 1300 m (Inger, 1954; Brown and Alcalá, 1955; Alcalá, 1962; Alcalá, 1986; Brown et al., 2000). Our Mt. Baloy expedition in 1989 first recorded the presence of this frog on Panay (Sison et al., 1995). Negros populations (expected to be conspecific with those on Panay) are only found near water during breeding; this species has most

often been collected in overhanging, streamside vegetation (Brown and Alcalá, 1955; Alcalá, 1967). As noted by Brown et al. (2000), the taxonomic status of the Visayan populations referred to *Rana everetti* is in need of further study.

Localities and specimens: (Site 2) PNM 1732–33; (Site 14) PNM 3771, 3800–03, 3806–14, 3817–24, 3896, 3913; (Site 39) CAS 124213, 124215–16.

***Rana* (= "*Fejervarya*") *vittigera* Wiegmann (Fig. 24)**

This species occurs in open, agricultural areas near sources of water (ponds, flooded rice fields). The distinctive, rapid honking call of this species can be heard in choruses of up to hundreds of individuals. This record appears to be the first published account of this species from Panay.

Localities and specimens: (Site 11) CMNH 4871–72, PNM 2593–94; (Site 19) PNM 2596–606; (Site 40) USNM 339991; (Site 41) CAS 124197; (Site 46) CAS 125360.

Family Rhacophoridae

***Polypedates leucomystax* (Gravenhorst) (Fig. 25)**

This common tree frog is widely distributed in Panay (Inger, 1954; Alcalá, 1986) in agricultural areas, forest edges, and disturbed forests. It ranges from near sea level to 1000 m on Negros (Alcalá, 1962) and was first documented on Panay by Inger (1954). Our specimens were collected in banana plantations and rice fields near the base of Mt. Madja-as and Mt. Baloy.

Localities and specimens: (Site 1) PNM 1107–09, 1209–27; (Site 2) PNM 1729–30; (Site 6) CAS 137599; (Site 7) PNM 1797–98; (Site 11) CMNH 4997–98, PNM 2560–61; (Site 13) TNHC 56336, 56338; (Site 14) PNM 3763, 3799; (Site 16) CAS 127512–14, 127540–58, 127592–95, 127608–10, 127647–49, 127657, 127670–76, 127680–97, 127701; (Site 17) CAS 127721–26; (Site 18) CAS 127841; (Site 24) FMNH 61485; (Site 25) PNM 1107–09; (Site 28) CAS 124110–13, 124420, 124422–25, 124581; (Site 29) USNM 339992–93; (Site 30) CAS–SU 11113–16, 14764, FMNH 40569, 44263; (Site 37) CAS 124114, 125034–37; (Site 39) CAS 124158, 124192, 124204–07; (Site 40) USNM 339994; (Site 41) CAS 124176, 125031–32; (Site 42) CAS–SU 23950–51, 23959–60, 23964–65; (Site 47) CAS 125342–43.

Reptilia

Testudines

Bataguridae

Cuora amboinensis amboinensis (Daudin) (Fig. 26)

This common species is found throughout the Philippines (Gaulke and Fritz, 1998) and on Panay (Gaulke, in press) in low elevation forests, agricultural areas, and near streams and swampy areas; it is generally considered nocturnal (Alcala, 1986). We have collected this species in stream-side habitats at low elevations on Panay.

Localities and specimens: (Site 7) PNM 1888–89, 1891–95; (Site 11) CMNH 5500, 5501, 5502; PNM 1288, 5657–58; (Site 23) USNM 78103–04, 78746–49; (Site 41) CAS 153872; (Site 45) CAS 185507; (Site 50) USNM 78081–102.

Squamata (Lizards)

Agamidae

Bronchocela cristatella (Kuhl) and *B. marmorata* (Gray)

These arboreal lizards (Alcala, 1986) are found from lowland cultivated areas to lower midmontane primary and secondary forests; they are most often encountered sleeping at night in stream-side vegetation. No suitable taxonomic reference is available for Philippine *Bronchocela* and so the true identities of Panay specimens referred to *B. cristatella* and *B. marmorata* are uncertain. There is little consensus regarding the identity of *Bronchocela* throughout the Visayas. Although specimens from Negros and Panay key out to earlier descriptions of both *Bronchocela marmorata* and *B. cristatella* (Taylor, 1922c; Alcala, 1986), both “species” appear to be highly variable and diagnostic characters vary ontogenetically. We consider it unlikely that two independent lineages occur in sympatry on Panay and, at present, we hold in abeyance the identity of these populations until a thorough taxonomic revision is available.

Localities and specimens: (Site 6) CAS 137605; (Site 22) CAS–SU 10948; (Site 23) USNM 77133–38, 78105–107; (Site 41) CAS 124333; (Site 47) CAS 125337–38.

Draco spilopterus (Weigmann) (Figs 27, 28)

This species is common at lower to mid-montane elevations and often is found in coconut groves and forest edges (Alcala, 1986; McGuire and Alcala, 2000). *Draco spilopterus* is the only *Draco* species currently recognized from the Visayan and Luzon aggregate island complexes, despite biogeographic and morphological evidence suggesting that Luzon and Visayan populations constitute independent evolutionary lineages (Taylor, 1922c; Heaney, 1985, 1986; McGuire and Alcala, 2000). *Draco spilopterus* may warrant further taxonomic attention once biochemical studies of species boundaries become available (Taylor, 1922c; McGuire and Alcala, 2000).

Localities and specimens: (Site 3) CAS 137578, 185504; (Site 4) PNM 1628–38; (Site 6) CAS 137608–609, 185505; (Site 7) PNM 1759–79; (Site 8) CAS 127886, 127916, 127961, 128031; (Site 11) PNM 1275–82, 2720–21; (Site 14) PNM 3769–70, 3878; (Site 18) CAS 127851–52; (Site 19) TNHC 58465–67, 58471–80, 58482–90, 58850; (Site 43) CAS 39686; (Site 44) CAS 125295, USNM 38990–96; (Site 47) CAS 125277–94.

Hydrosaurus pustulatus (Eschscholtz) (Figs. 29, 30)

The Mt. Madja-as specimens were collected in overhanging stream-side vegetation. On Mt. Baloy we also collected a specimen in similar riparian habitats. These large omnivorous agamids can be found on trees and shrub-layer vegetation, overhanging streams and rivers (Alcala, 1986). The taxonomy of Philippine *Hydrosaurus* is in need further taxonomic studies.

Localities and specimens: (Site 11) CMNH 5043; (Site 13) TNHC 56762; (Site 22) USNM 77091–103, 85073–74; (Site 44) CAS 125336, USNM 38988–89; (Site 50) 77104–28, 78168–87.

Gonocephalus sp.

This genus was reported as an island record for Panay from site 2 by Sison, et al. (1995). The name *G. sophiae* has been applied to Negros populations (Taylor, 1922c; Alcala, 1986) and we might expect that if Negros populations are indeed *G. sophiae* (and this name applies to a distinct lineage that is independent from *G. semperi*), specimens from Panay might be referable to this species as well (see Gaulke, in press). At present, no suitable taxonomic reference exists, and species boundaries are unclear. Due to this fact, we do not apply a specific epithet to this population. Philippine populations of the genus *Gonocephalus* are greatly in need of taxonomic review.

Localities and specimens: (Site 2) PNM 1130–32; (Site 14) PNM 3858.

Gekkonidae

Cosymbotus platyurus (Schneider)

We found specimens of this common house gecko species in both the city and in agricultural areas; they are widely distributed on Panay (Brown and Alcala, 1978) and are usually encountered under lights.

Localities and specimens: (Site 7) PNM 1803, 1815–16; (Site 8) CAS 128020; (Site 11) CMNH 5137, PNM 1261–74; (Site 19) CMNH 5089–96, 5098–104, PNM 2722–36; (Site 22) USNM 78776–832, 103480; (Site 23) USNM 77144–57, 339998–340010; CAS–SU 9613; (Site 26) PNM 1234–44, 1247, 1249; (Site 29) USNM 339995–97; (Site 34) CAS–SU 9612, 12021; (Site 40) USNM 34011–12; (Site 50) FMNH 41302.

Cyrtodactylus annulatus (Taylor) (Fig. 32)

Brown and Alcala (1978) and Alcala (1986) report this species in forested areas ranging from sea level to 1200 m on the nearby land-bridge islands of Negros, Cebu, and Inampulugan (Site 42) and its presence on Panay is not surprising. Nevertheless, this report and that of Gaulke (in press) appear to be the first records of this species from Panay. Brown and Alcala (1978) reported that this species has been collected on the forest floor, from under logs, beneath bark, and on the trunks of trees. We found Panay specimens in secondary forest on root masses of trees protruding through eroding banks along a large river at the base of Mt. Madja-as. Predation on this species by flying snakes (*Chrysopelea paradisi*) was observed in these same microhabitats.

Locality and specimens: (Site 28) CAS 124614–15, 124768–78 (Site 42) CAS–SU 28009–10, 28013–14, 28016–19, 28031, 28036–41, 28044–46, 28050–60.

Cyrtodactylus philippinicus (Steindachner) (Fig. 33)

This species of *Cyrtodactylus* is found in a variety of habitats in the forest, particularly in rotting logs (Brown and Alcala, 1978; Alcala, 1986) and has been collected from sea level to nearly 1200 m (Brown and Alcala, 1978). In the Visayas, this species also has been collected on the nearby land-bridge islands of Negros, Pan de Azucar, and Boracay but never before on Panay. The specimens from Mt. Madja-as were collected in primary forest, during the day, under loose tree bark.

Localities and specimens: (Site 6) CAS 137607; USNM 496868; (Site 8) CAS 127883; (Site 11) CMNH 5125–28, PNM 2751–53; (Site 13) TNHC 56339; (Site 18) 127864, 127869; (Site 28) CAS 124783–84; (Site 41) CAS 124046, 124780–82.

Gehyra mutilata (Weigmann) (Fig. 34)

This common and widely-distributed lizard is consistently found not only around human habitation (in darker areas, away from lights), but also in gardens and forested areas on trees (Brown and Alcala, 1978; Alcala, 1986).

Localities and specimens: (Site 2) PNM 1682–86; (Site 3) CAS 137579; (Site 4) PNM 1649–53; (Site 7) PNM 1824; (Site 8) CAS 127888, 127922–29, 127948–52, 127964, 127975–76, 127999–128000, 128054–55; (Site 11) CMNH 5105–16, 5198, PNM 1250–58, 2737–46; (Site 16) CAS 127504, 127607; (Site 18) CAS 127804, 127866; (Site 19) PNM 2737–46; (Site 23) USNM 77158, 78834–35; (Site 26) PNM 1245–49; (Site 28) CAS 124434–36, 124616–19; (Site 29) USNM 340013–14; (Site 37) CAS 125029; (Site 39) CAS 124118–120, 124161–170; (Site 40) USNM 340015; (Site 41) CAS 124180–83; (Site 42) CAS–SU 28012, 28047–49; (Site 44) CAS 124505–510; (Site 46) CAS 124687–88; (Site 47) CAS 124682–86, 125129–31; (Site 48) CAS 124511–12; (Site 50) FMNH 41383.

Gekko gecko (Linnaeus)

This common species is found around human habitation and in forest adjacent to disturbed areas. We collected specimens in secondary forest near the base of Mt. Madja-as.

Localities and specimens: (Site 1) PNM 1056–63; (Site 2) PNM 2667; (Site 7) PNM 1062–1063, 1792–96; (Site 8) CAS 128004; (Site 11) CMNH 5018–25, PNM 1282, 1330, 2662–69; (Site 16) CAS 127582; (Site 17) CAS 127745; (Site 19) PNM 2665; (Site 23) CAS–SU 9585–88; USNM 77142–43, 340018–19; (Site 28) CAS 124979; (Site 29) USNM 340016–17; (Site 31) PNM 1143; (Site 35) CAS 124393, 124318, 124866–75; (Site 37) CAS 124315–17, 124929–49; (Site 39) CAS 124389–92; (Site 41) CAS 124319, 124580; (Site 42) CAS–SU 27929; (Site 44) CAS 125251; (Site 46) CAS 125249–50; (Site 47) CAS 125247–48; (Site 49) CAS–SU 9589; (Site 50) FMNH 41377–81, 41376.

Gekko gigante Brown and Alcala (Figs. 35, 36)

Gekko gigante was described by Brown and Alcala (1978) from the tiny land-bridge islands of Gigante

North and Gigante South, off the northeast coast of Panay (Fig. 2). This species has not been studied since its 1968 discovery until a recent visit to the type locality by RMB and A. Alcala in June 2000. We found *G. gigante* in small sea-side caves in karst limestone outcrops along the south coast of Gigante South. The northeast coast is the best place to survey for this species on Panay if suitable limestone habitat can be located.

Localities and specimens: (Site 35) CAS 124318, 124866–75 (Site 37) CAS 124315–17, 124929–49.

***Gekko mindorensis* Taylor (Fig. 37)**

Brown and Alcala (1978), and Alcala (1986) report that individuals of this species are common on walls of caves, on tree trunks, and in leaves around the buttresses of trees. Elsewhere in the Visayas this species has been reported from Negros, Cebu, and Caluya (Brown and Alcala, 1978). We have caught this species on cement walls, abandoned buildings in the forest, in road-cut culverts, and on large dead tree trunks and stumps. Sison et al. (1995) reported this as an island record from Site 29. The taxonomic distinctiveness of this species requires verification; recent data suggest the widespread *G. mindorensis* may be conspecific with *G. kikuchii* from Taiwan (Crombie and Ota, unpublished data; see also comment by Taylor, 1922c).

Localities and specimens: (Site 8) CAS 127882, 127884–85, 128021; (Site 11) One uncataloged specimen, deposited in PNM; (Site 16) CAS 127700; (Site 18) CAS 127817; (Site 28) CAS 124767; (Site 29) PNM 2500; (Site 39) CAS 124136.

***Hemidactylus frenatus* Schlegel in Dumeril and Bibron**

This common house gecko is widespread on Panay and often is associated with *Cosymbotus platyurus* (Alcala, 1986) in well lighted areas in human habitation. We collected several specimens near the base of Mt. Madja-as on walls of houses in agricultural areas.

Localities and specimens: (Site 3) CAS 137580, USNM 496869–70; (Site 7) PNM 1801–02, 1804–14; (Site 8) CAS 127878–81, 127897, 127913–14, 127930–45, 127953–58, 127963, 127977–78, 128001–03, 128022–26, 128034–35, 128056–57, 136742–44; (Site 11) CMNH 5148–54, PNM 1259–60, 1646–48, 2771–76; (Site 16) CAS 127505–07, 127515–16, 127583, 127615–16, 127642–46, 127652–56, 127658–59, 127699; (Site 17) CAS 127710–20, 127727–44, 127748–65, 127795–99, 136741; (Site 18) CAS 127805–14, 127818–26,

127829–40, 127848–50, 127865; (Site 19) CMNH 5129–36, 5139–47, PNM 2754–70; (Site 23) USNM 78833, 78836–39; (Site 26) PNM 1245–1246; (Site 28) CAS 124081–92, 124427, 124663, 125002–12; (Site 29) USNM 340021–27; (Site 33) USNM 340028–32; (Site 35) CAS 124363, 124504; (Site 37) 124364–72, 124357–62, 124582–610, 124662; (Site 39) CAS 124137–43, 124217–42; (Site 40) 340034–41; (Site 41) CAS 124373–85, 124664–81, 125013; (Site 42) CAS–SU 28007–08, 28011, 28021, 28034–35, 28042–43; (Site 44) CAS 124466, 124526–58 [Nadulao Island]; (Site 46) CAS 124458–65, 125315–30, 124736–66; (Site 47) CAS 124448–57, 125128, 125313–14; (Site 50) FMNH 41384–86.

***Hemidactylus stejnegeri* Ota and Hikida**

Previously referred to *H. garnoti* (Brown and Alcala, 1978), the status of Philippine populations was clarified by Ota and Hikida (1989) and Ota et al. (1993). Sison et al. (1995) reported this species as an island record for Panay.

Locality and specimen: (Site 25) CMNH 3225.

***Hemiphyllodactylus insularis* Taylor**

While Brown and Alcala (1978) referred Philippine (and Panay Island) populations of *Hemiphyllodactylus* to *H. typus*, collections in USNM contain males and are not, therefore, the widespread unisexual *H. typus*, but probably are better referred to Taylor's *H. insularis* (R. Crombie, personal communication.).

Localities and specimens: (Site 3) CAS 137581–83; (Site 8) CAS 127889, 127965–71; (Site 18) CAS 127855–57.

***Lepidodactylus lugubris* (Dumeril and Bibron)**

This lowland gecko is common in patchy distributions and found in leaf axils, under bark, in tree holes, in coconut groves, and associated with large rocks in coastal areas (Brown and Alcala, 1978; Alcala, 1986). Though reported from Negros, Cebu, Inampulugan, Boracay, Gigante, and Pan de Azucar (Brown and Alcala, 1978), this species has not yet been reported from Panay.

Localities and specimens: (Site 8) CAS 127947, 127959, 127979, 127982–87, 127989, 128005–07, 128010, 128012–14, 128017, 128043–44, 128046–50, 128059, 154716; (Site 28) CAS 124579; (Site 37) CAS 124200, 125030, 125033; (Site 39) CAS 124116–17; (Site 41) CAS 124981–125000; (Site 42) CAS–SU 28015, 28061; (Site 44) CAS 124561–63; (Site 46) CAS 124492.

***Lepidodactylus planicaudus* Stejneger**

Alcala and Brown (1978) recorded this species in coconut trees, mangroves, and in fern axils; they have also been taken on tree trunks in forests from sea level to 700 m. Elsewhere in the Visayan Aggregate Island Complex it is known from Cebu, Guimaras, Caluya, Masbate and Boracay (Brown and Alcala, 1978).

Localities and specimens: (Site 3) CAS 139939; (Site 8) CAS 127921, 127980–81, 127988, 127990, 128008–09, 128011, 128015–16, 128018–19, 128045, 128051–53; (Site 16) CAS 127698; (Site 17) CAS 127709; (Site 39) CAS 124115, 124134; (Site 46) CAS 124823–26.

Scincidae***Brachymeles boulengeri taylori* Brown (Figs. 38, 39)**

Usually encountered in agricultural areas (especially coconut plantations) adjacent to forest, this species most often is collected from its preferred microhabitat, inside rotting coconut logs. It has also been collected in mature and secondary forest, from sea level to 1200 m on numerous islands in the Visayas (Brown and Alcala, 1980) but this is the first record from Panay.

Localities and specimens: (Site 1) PNM 1148; (Site 25) PNM 1148; (Site 39) CAS 124157; (Site 41) CAS 124044 (Site 42) CAS 27930–31, 27946–51, 27953, 27973–84, 27987–93.

***Brachymeles talinis* Brown**

This skink occupies decaying vegetation and humus on the floor of primary and, occasionally, secondary forest (Brown and Alcala, 1980; Alcala, 1986). Alcala and Brown (1980) reported its elevational range from sea level to approximately 1200 m.

Localities and specimens: (Site 6) 137603; (Site 8) CAS 127870–75, 127962, 128029–30, 154689; (Site 14) PNM 3852, 3856, 3859, 3909–10; (Site 16) CAS 127517–39, 127584–90, 127606, 127663–68; (Site 28) 154692, 200522–31; (Site 39) CAS 124148, 200521; (Site 42) CAS–SU 27972, 27996–97; (Site 50) CAS 137603.

***Brachymeles tridactylus* Brown (Fig. 40)**

This species has been collected under logs, humus, and other debris in forested regions from sea level to approximately 900 m (Brown and Alcala, 1980; Alcala, 1986). On Mt. Madja-as we found them under logs in well-regenerated second growth forest below 200 m.

Localities and specimens: (Site 3) CAS 137566–75; (Site 6) CAS 137602, 137604; (Site 8) CAS 127876–77, 127915, 127974, 128027–28, 128037–42; (Site 11) PNM 5514–15; (Site 42) CAS–SU 27950, 27952, 27985–86, 28456.

***Dasia grisea* (Gray)**

In the Philippines, this species has been recorded from the islands of Mindoro, Luzon, and Marinduque (Brown and Alcala, 1980). Its inclusion in this paper is based on a single record from Semirara Island, a small island south of Mindoro that is included in the political boundary of Antique province but is on the land-bridge to Mindoro. We do not expect this species to be discovered on Panay and we do not regard it as a Visayan Aggregate Island complex resident.

Locality and specimen: (Site 18) CAS 134218.

***Dasia semicincta* (Peters)**

A large lowland species, previously reported only from Mindanao in the Philippines (Brown and Alcala, 1980; Alcala, 1986). Outside of the Philippines *D. semicincta* is known from Borneo (Brown and Alcala, 1980). This is the first record of this species from Panay; it also is a substantial range extension in need of verification.

Locality and specimen: (Site 23) USNM 78840.

***Emoia atrocostata* (Lesson)**

This species of skink is common in mangroves and can be found active on tree trunks, in tree holes, and in rock crevices (Alcala and Brown, 1967; Brown and Alcala, 1980; Alcala, 1986). Taylor (1922c) reported that this species swims in brackish water, burrows in sand, and feeds on small crabs. On Panay and Negros, mangrove forests have nearly all been cleared, possibly rendering this species rare in recent collections.

Localities and specimens: (Site 16) CAS 127638–39; (Site 18) CAS 127842–45; (Site 22) CAS–SU 13585; (Site 23) USNM 77139, 78411, 78841, 80934; (Site 37) CAS 125040; (Site 41) CAS 124329–32, 124620–24; (Site 42) CAS–SU 27920; (Site 47) CAS 125335; (Site 50) USNM 77141.

***Lamprolepis smaragdina philippinica* (Mertens)**

This skink is common in coconut groves and gardens and a variety of natural vegetation types (Alcala, 1986). Near Mt. Madja-as and Mt. Baloy we observed them on coconut trunks at low elevations.

Localities and specimens: (Site 4) PNM 1639; (Site 7) PNM 1780, 1782, 1786; (Site 8) CAS 127887,

127917–20, 127946, 127991–98, 128058, 128060–61; (Site 11) CMNH 5038–40, PNM 1283, 2681–82; (Site 14) PNM 3798; (Site 16) CAS 127508, 127612–14, 127640–41, 127669; (Site 17) CAS 127747, 127794; (Site 18) CAS 127853–54; (Site 19) TNHC 56472–73; (Site 28) 124053–57; (Site 35) CAS 124198, 124711–13; (Site 39) CAS 124201–02; (Site 40) USNM 340061; (Site 42) CAS–SU 27954–62, 27969; (Site 44) CAS 125301; (Site 46) 125298–300; (Site 47) CAS 124447, 125296–97.

***Lipinia pulchella taylori* (Brown and Alcala)**

This widely distributed arboreal skink had not been reported from Panay prior to our visits to Mt. Majadas. Previously, *L. p. taylori* had only been known from Negros (Brown and Alcala, 1980). Brown et al. (1996; 2000) have collected specimens from Luzon that key out to this subspecies, potentially indicating the need for a review of Brown and Alcala's (1980) taxonomy of this species. This is a new island record for Panay.

Localities and specimens: (Site 11) CMNH 5083; (Site 25) PNM 1156.

***Mabuya indepressa* Brown and Alcala**

Sison et al. (1995) reported this species as an island record, collected at about 200 m on Mt. Baloy. Well known from forested, montane habitats on Negros and Cebu (Brown and Alcala, 1980), this species is found in leaf litter, stumps and fallen logs, and around tree buttresses.

Localities and specimens: (Site 1) PNM 1149; (Site 9) PNM 1153–55; (Site 11) CMNH 5119–22, 5199–202, PNM 2747–49, 5511–13; (Site 13) one uncataloged specimen deposited in PNM; (Site 16) CAS 127596–97, 127599, 127601–02, 127604–05; (Site 18) CAS 127863; (Site 25) CMNH 3247, PNM 1151–1152.

***Mabuya multicarinata borealis* Brown and Alcala (Fig. 41)**

This subspecies commonly is found under tree bark, logs and piles of vegetation (Brown and Alcala, 1980; Alcala, 1986); in the Visayas it has been collected on Negros, Caluya, Semirara, Gigante, Pan de Azucar, and Cebu, but this is the first record from Panay. Brown and Alcala (1980) reported finding one specimen as high as 1500 m on Luzon island.

Localities and specimens: . (Site 2) PNM 1657–60, 1668–80; (Site 6) USNM 496871; (Site 16) CAS 127598, 127600, 127603, 127650–51; (Site 18) CAS 127862, 127867–68; (Site 28) CAS 124107–109, 124971–78; (Site 35) CAS 124493–97; (Site 36) CAS

124199, 125039; (Site 37) CAS 125038; (Site 41) CAS 124050.

***Mabuya multifasciata* (Kuhl)**

This species was found in a variety of habitats from beaches and low elevation agricultural areas, to disturbed forest adjacent to primary forest on Mt. Madjas. Though known to occur throughout the Philippines, in the Visayas, this species has only been reported from Negros (Brown and Alcala, 1980); this is the first published account from Panay.

Localities and specimens: (Site 2) PNM 1661–65; (Site 3) CAS 137585, USNM 496872; (Site 4) PNM 1640–45, 1655–56; (Site 6) CAS 137610–12, 139147; (Site 7) 1781, 1783; (Site 11) CMNH 5203–04, PNM 5510; (Site 14) PNM 3845–46, 3853; (Site 22) CAS–SU 13632; (Site 25) PNM 1149–55; (Site 42) CAS–SU 27968, 27971, 27998; (Site 44) CAS 125264–66; (Site 46) CAS 125334; (Site 47) CAS 125262–63, 125333; (Site 50) FMNH 41389–404.

***Parvoscincus sisoni* Ferner, Brown and Greer**

All specimens of this recently-described species were collected during the day from beneath loose soil and leaf litter in the forest between 900 and 1125 m (Ferner et al., 1997). At present, this species is known only from Mt. Madjas; the only other member of the genus is from Palawan Island (*P. palawanensis*).

Locality and specimens: (Site 11) CMNH 3797–99, PNM 2308–10.

***Sphenomorphus arborens* Taylor**

This forest species is found under logs and leaves and occasionally on buttresses at the base of tree trunks (Brown and Alcala, 1980; Alcala, 1986). Our specimens were collected in primary forest between 1400 and 1600 m in pit-fall traps.

Localities and specimens: . (Site 6) CAS 137644; (Site 11) CMNH 5062–74, PNM 2684–710; (Site 14) PNM 3720, 3746–48, 3753, 3867–69, 3871, 3875, 3898, 3901–03; (Site 41) CAS 124048–49.

***Sphenomorphus coxi divergens* Taylor**

This species is often found at the forest edge and in forest gaps. It is widely-distributed in the archipelago (Brown and Alcala, 1980; Alcala, 1986). *Sphenomorphus coxi divergens* previously has been reported from Luzon, Marinduque, and Mindoro but not the Visayas (Brown and Alcala, 1980). This is the first published record of a specimen from Panay.

Locality and specimens: (Site 11) CMNH 5123, PNM 2750.

***Sphenomorphus cumingi* (Gray)**

This large forest species is found around fallen logs and tree buttresses and is believed to be limited to low to medium elevations (Brown and Alcala, 1980; Alcala, 1986). *Sphenomorphus cumingi* previously has been reported from islands in the Luzon and Mindanao aggregate island complexes; this is the first published record of a specimen from Panay.

Locality and specimen: (Site 28) CAS 124779.

***Sphenomorphus jagori grandis* Taylor (Fig. 42)**

This large skink is found under rotting logs, in sun spots in forested and disturbed areas, and along streams (Brown and Alcala, 1980; Alcala, 1986).

Localities and specimens: . (Site 6) 137645–48; (Site 14) PNM 3724–5, 3755; (Site 16) CAS 127660–62, 127677; (Site 28) CAS 125267–76, 154659–68; (Site 37) CAS 124835, 185508; (Site 41) CAS 185509–516.

***Sphenomorphus steerei* Stejneger**

We found this species on Mt. Madja-as in leaf litter in montane forest. Brown and Alcala (1980) report that this species is common in leaf litter of primary forest and in secondary growth.

Localities and specimens: (Site 3) CAS 137600–601, 139169–70, USNM 496873–74; (Site 11) CMNH 5026–37, PNM 2670–80; (Site 14) PNM 3708–09, 3721–23, 3726, 3749–52, 3754, 3775–81, 3786–87, 3797, 3826–29, 3836–42, 3847–51, 3854–55, 3861, 3870, 3872–74, 3876–77, 3879–81, 3890–92, 3914; (Site 25) PNM 1159; (Site 28) CAS 124437–38, 124577–78; (Site 36) CAS 124830; (Site 37) CAS 124827–29, 124839; (Site 39) CAS 125091; (Site 47) CAS 124625–61, 125064, 125090.

***Tropidophorus grayi* Günther (Fig. 43)**

Sison et al.'s (1995) Mt. Baloy specimen was the first record of this species from Panay. We also found a specimen at the base of Mt. Madja-as underneath a rock on the edge of a small stream in second growth forest.

Localities and specimens: (Site 11) CMNH 5117; (Site 13) One uncataloged specimen deposited in PNM.

Varanidae***Varanus salvator nuchalis* (Günther) (Figs. 44, 45)**

This monitor lizard is found in agricultural and disturbed areas, mangrove swamps, and forested areas from sea level to about 1200 m (Alcala, 1986; Gaulke, 1991a, 1991b, 1992). On Mt. Madja-as we collected one specimen during the day in second growth forest where it was active near a small stream.

Localities and specimens: (Site 1) PNM 1142; (Site 11) PNM 5660; (Site 22) CAS 11018; (Site 31) PNM 1142; (Site 37) CAS 124879; (Site 44) CAS 124881; (Site 47) CAS 124880; (Site 50) USNM 77129–32, 80115–19; FMNH 41417–18.

Squamata (Snakes)**Acrochordidae*****Acrochordus granulatus* (Schneider)**

Found in mangroves and at river mouths, this species feeds exclusively on fish and is widely distributed and common (Alcala, 1986). We are not aware of other published accounts of this species from Panay.

Locality and specimens: (Site 23) USNM 78412, 78744–45, 78906, CAS–SU 8695, 8769.

Boidae***Python reticulatus* (Schneider) (Fig. 46)**

While this snake is considered widely distributed and common in the tropical rain forests as well as near human habitation (Alcala, 1986), only one specimen has been collected on Panay Island (Leviton, 1963c; see also Gaulke, in press).

Locality and specimen: (Site 44) CAS 124916.

Colubridae***Ahaetulla prasina preocularis* (Taylor) (Fig. 47)**

This snake may be found in low trees and shrubs from sea level to about 800 m on Panay (Leviton, 1963c, 1968; Alcala, 1986). The specimens from Mt. Madja-as were collected from vegetation overhanging a small stream at low elevation.

Localities and specimens: (Site 2) PNM 1689; (Site 7) PNM 1787; (Site 11) CMNH 5084–85, PNM 2716; (Site 14) PNM 3825; (Site 29) USNM 340042; (Site 44) CAS 125339; (Site 50) FMNH 41108.

***Boiga angulata* (Peters)**

We found our specimen in a coconut tree in a clearing adjacent to virgin forest at 900 m on Mt. Madja-as. While this species is known from Negros (Leviton, 1970a), until this report and that of Gaulke (in press) it has never been recorded on Panay.

Locality and specimen: (Site 11) CMNH 5504

***Boiga cf. cynodon* (Cuvier in F. Boie)**

This species has been found in forested areas at low altitudes on Palawan, Mindanao, and Luzon (Leviton, 1963c, 1970a; Alcalá, 1986) but previously it has not been reported in the Visayas (see also Gaulke, in press).

Locality and specimen: (Site 41) CAS 125173.

***Boiga cf. dendrophila* (Boie)**

Mangrove snakes usually are found in branches of low trees and bushes in forested areas (Leviton 1968; Alcalá, 1986) at low elevations. This is the first record of a species in this complex from Panay.

Localities and specimens: (Site 28) CAS 124388; (Site 39) CAS 124386–87.

***Calamaria geravaisi* Dumeril and Bibron**

A burrowing snake, this species is commonly found in the humus under rotting logs and feeds on earthworms (Leviton, 1963c; Inger and Marx, 1965; Alcalá, 1986). On Mt. Madja-as we found specimens under rotten logs and large flat rocks.

Localities and specimens: (Site 2) PNM 1087; (Site 11) CMNH 5081–82, PNM 2714–15; (Site 23) CAS–SU 15953–57, 15962–65; (Site 44) CAS 124612.

***Cerberus rynchops* (Schneider)**

This aquatic snake has been collected in brackish swamps, mangroves, fish ponds, and river estuaries in coastal areas (Gyi, 1970; Alcalá, 1986)

Localities and specimens: (Site 1) PNM 1053–55, 1077–83; (Site 20) CAS–SU 13079; (Site 22) CAS–SU 8696–97, 8719; CAS–SU 12380, CM R2423, R2426; (Site 23) USNM 77159–478, 78907–19; (Site 40) 340043; (Site 50) FMNH 41115–17.

***Chrysopelea paradisi* Boie**

This species was not known from Panay (Leviton, 1963, 1964a) until Sison, et al. (1995) reported it as an island record from Site 1. On Mt. Madja-as we found this arboreal snake during the day in root masses overhanging a river bank; one specimen was preying on a *Cyrtodactylus annulatus* when captured.

We have also observed this species in coconut groves at sea level near the town of San José (site 19).

Localities and specimens: (Site 1) PNM 1050; (Site 8) CAS 128032; (Site 11) CMNH 5041–5042, PNM 2683; (Site 19) TMM 56474; (Site 27) CAS 185–672; (Site 36) CAS 125172; (Site 46) CAS 125331–32.

***Cyclocorus lineatus alcalai* Leviton**

We found our specimens in habitats ranging from disturbed second growth at sea level to first growth forested riparian sites at 1400 m. At the time of its description (Leviton, 1967), this subspecies was known only from the nearby islands of Negros and Cebu (Fig. 2). This is the first published account of this species from Panay.

Localities and specimens: (Site 1) PNM 1047, 1065; (Site 2) PNM 1065, 1688; (Site 3) CAS 137576; (Site 6) CAS 137606; (Site 11) CMNH 5086–87, PNM 2717–18; (Site 14) 3884–85, 3912; (Site 16) CAS 127702, 127706; (Site 28) CAS 124051–52, 124421; (Site 37) CAS 125171; (Site 47) CAS 124445.

***Dendrelaphis caudolineatus terrificus* (Peters)**

This subspecies is known from Panay and Negros and usually is found in forested and cultivated areas in or along swamps and streams (Leviton, 1970b; Alcalá, 1986). Sison et al. (1995) reported this as an island record from 200 m on Mt. Baloy. The specimen from Mt. Madja-as was sleeping in bushes near a river when captured.

Localities and specimens: (Site 4) CAS 1654; (Site 8) CAS 127896, 128033; (Site 11) CMNH 5080; (Site 13) CMNH 3254; (Site 16) CAS 127703–705, 127707–708; (Site 18) CAS 127828, 127847, 127859; (Site 28) CAS 125170; (Site 39) CAS 124203, 185673–74; (Site 42) CAS–SU 28004; (Site 50) FMNH 41093–96.

***Dendrelaphis pictus pictus* (Gmelin) (Fig. 48)**

This common snake is arboreal and usually found near streams, in vegetation surrounding flooded rice fields, and in swampy areas (Leviton, 1963c, 1970b; Alcalá, 1986). The Mt. Madja-as specimens were collected at night where they slept in stream-side vegetation.

Localities and specimens: (Site 1) PNM 1049, 1071; (Site 3) CAS 137577; (Site 7) PNM 1788–90; (Site 9) PNM 1071; (Site 11) CMNH 5078–79, PNM 2713; (Site 14) PNM 3843–44; (Site 22) CAS–SU 8660–70, 8718, 14932, 14936–37, CMNH 2408–13,

CM R2226, R2408–13; (Site 23) CAS–SU 8698–99, 8708–710; USNM 77419–591, 340044–51; (Site 30) CAS–SU 14931 ; (Site 38) CAS 200256; (Site 44) CAS 125255–61; (Site 46) CAS 125254; (Site 47) CAS 125252–53; (Site 48) CAS 124725; (Site 50) FMNH 4109–104, 41106, USNM 77592–609.

***Elaphe erythrura psephenoura* Leviton**

This is a common lowland snake, often found near human habitations (Leviton, 1979; Alcalá, 1986). On Mt. Madja-as we collected one specimen from the forest floor where it was active at midday.

Localities and specimens: (Site 1) PNM 1048, 1051; (Site 11) PNM 5662; (Site 22) CAS–SU 12389, 13212–13; (Site 23) USNM 340052; (Site 30) CAS–SU 13217; (Site 38) CAS 131700; (Site 42) CAS–SU 28001; (Site 47) CAS 125141–42, 125340.

***Gonyosoma oxycephala* (Reinwardt in F. Boie)**

This is an arboreal snake that is found in disturbed and primary forests (Alcalá, 1986). On Mt. Madja-as we collected one specimen that was active at mid day in a tree above a large river (4 m from the ground). This record, and that of Gaulke (in press) are the first published accounts of this species from Panay.

Localities and specimens: (Site 1) PNM 1084; (Site 9) PNM 1084; (Site 11) CMNH 5503; PNM 5659.

***Hologerrhum dermali* Brown, Leviton, Ferner, and Sison**

We first collected this newly-described species (Brown et al., this issue) between 1030 and 1510 m in climax forest on Mt. Madja-as. Specimens were collected in a dry stream bed and in leaf litter on the forest floor 30 m from a large river. One specimen from the Municipality of San Remigio was collected at approximately 700 m above sea level. Recent survey work in NW Panay suggests that this species also occurs in forested areas at lower elevations (Gaulke, in press).

Localities and specimens: (Site 11) CMNH 5075, PNM 2711 (14) PNM 3704.

***Lycodon aulicus capucinus* (H. Boie in F. Boie) (Fig. 49)**

This common, widespread, nocturnal snake is often found in gardens, agricultural areas, and around houses (Leviton, 1965; Alcalá, 1986). Our specimens were collected near rice fields away from forested areas.

Localities and specimens: (Site 1) PNM 1072–75; (Site 3) CAS 137584; (Site 8) CAS 127960; (Site 12) PNM 1072; (Site 13) PNM 1380; (Site 22) CAS–SU 8671, 8700–01, CMNH 2443, CM R2443; (Site 23) USNM 77616, 340053; (Site 26) PNM 1073–75; (Site 47) CAS 125341.

***Oligodon modestum* (Günther)**

This species is found under rotting logs and forest floor debris; it is known from sea level to 400 m (Alcalá, 1986). In the Visayas, this species was only known from Negros (Leviton, 1963a) before Sison et al. (1995) first reported it on Panay.

Localities and specimens: (Site 1) PNM 1066; (Site 2) PNM 1067; (Site 14) PNM 3790, 3866.

***Psammodynastes pulverulentus* (H. Boie in F. Boie)**

Leviton (1963c; 1983) and Alcalá (1986) report this snake as common up to elevations of 1000 m or more in moist forests on Negros Island; Leviton's (1963c) listing of this species from Panay was not repeated in his 1983 review of the genus in the Philippines and no specimens were reported from Panay in the later paper (Leviton, 1983). This account and that of Gaulke (in press) appears to be the first vouchered records of this species from Panay.

Localities and specimens: (Site 1) PNM 1068; (Site 2) PNM 1069; (Site 25) PNM 1067, 1070.

***Pseudorabdion mcnamarae* Taylor**

Prior to Sison et al. (1995) this species was known only from Negros and Luzon (Brown and Leviton, 1959; Alcalá, 1986). Specimens from Mt. Baloy were collected at 950 m under rotting logs in original forest.

Locality and specimens: (Site 13) Two uncataloged specimens in PNM (PNM Field Numbers 163 and 209).

***Pseudorabdion oxycephalum* (Günther)**

Previously considered a rare snake endemic to Negros Island, this species is now known from other localities in the Luzon and Mindanao aggregate island complexes (Brown and Leviton, 1959; Leviton, 1963c; Alcalá, 1986; Brown et al., 1999). This is the first published record from Panay. *Pseudorabdion oxycephalum* is been found in humus and under rotting logs from sea level to about 750 m.

Localities and specimens: (Site 6) CAS 137643; (Site 39) CAS 124174, 124193; (Site 41) CAS 124043.

***Pseudorabdion talonuran* Brown, Leviton and Sison**

The discovery of this new species at high elevations was surprising. Both specimens were found under logs on Mt. Madja-as in forest classified as the transition zone between mixed dipterocarp (submontane) and mossy (upper montane; Whitmore, 1984). The holotype was found at 1500 m and the paratype at 1410 m.

Locality and specimens: (Site 11) CMNH 5076, PNM 2712.

***Tropidonophis negrosensis* (Taylor)**

This species of water snake is common along forest streams from sea level to about 700 m (Leviton, 1963c; Alcalá, 1986; Malnate and Underwood, 1988). The specimen from Mt. Madja-as was found on a river bank at midday.

Localities and specimens: . (Site 3) CAS 185749; (Site 6) CAS 137613; (Site 11) CMNH 5124; (Site 14) PNM 3911; (Site 22) CAS-SU 15971; (Site 28) CAS 124611; (Site 41) CAS 124047.

***Zaocys luzonensis* Gunther**

A common tropical forest snake, this species ranges from sea level to over 1100 m (Leviton, 1983; Alcalá, 1986; Ross et al., 1987). On Mt. Madja-as, we found two specimens active at midday in disturbed forest at low elevation.

Localities and specimens: (Site 1) PNM 1052; (Site 2) USNM 269078; (Site 7) PNM 1791; (Site 11) CMNH 5505; PNM 5663.

Elapidae

***Calliophis calligaster gemianulis* (Peters)**

We collected one specimen on Mt. Madja-as at approximately 800 m on a mountain path away from water. They have previously have been found in a variety of semifossorial habitats associated with regenerated and climax forest (Leviton 1963b, 1963c; Alcalá, 1986)

Localities and specimens: (Site 11) CMNH 5088, PNM 2719; (Site 13) PNM 1379; (Site 21) UPLB 2184; (Site 22) CM R2581; (Site 23) CAS-SU 12966-68; (Site 44) CAS 125364; (Site 47) CAS 125363.

***Hydrophis belcheri* Gray**

This species has been recorded from the Visayan sea and is thought to be rare (Alcalá, 1986).

Localities and specimens: (Site 5) USNM 38588; (Site 37) FMNH 202832-36, 202838, 202840-42.

***Hydrophis cyanocinctus* Daudin**

Alcalá (1986) mentioned records from the Visayan Sea.

Locality and specimens: (Site 37) FMNH 202843-54.

***Hydrophis elegans* Gray**

Locality and specimen: (Site 5) USNM 38589.

***Hydrophis inornatus* Gray**

Locality and specimen: (Site 23) CAS-SU 8778.

***Lapemis hardwickii* Gray**

Alcalá (1986) reported this species from the Visayan sea; he noted that specimens were collected by trawling.

Localities and specimens: (Site 23) USNM 77610-15.

***Laticauda colubrina* Schneider**

This sea snake is found among rocks and in coral reef areas near shore; it is commercially used for its meat and hide (Alcalá, 1986).

Locality and specimens: (Site 37) FMNH 202797-801, 202804-808, 202810.

Typhlopidae

***Ramphotyphlops braminus* (Daudin)**

This species is common under rocks and other debris in agricultural areas. It can also be found in similar microhabitats along the edges of forested areas (Alcalá, 1986). Taylor (1922d) reported catching many specimens under rocks immediately following rains.

Localities and specimens: . (Site 1) PNM 1044-46; (Site 8) CAS 127972, 128036; (Site 17) CAS 127746; (Site 18) CAS 127846, 127858, 127860; (Site 30) CAS-SU 12544-49; (Site 37) CAS 125041; (Site 46) CAS 124503.

***Ramphotyphlops cumingii* (Gray)**

Alcalá (1986) reports this blind snake is found in epiphytic ferns in the trees of moist forests at low to medium elevations. In all of his field work, Taylor (1922d) was unable to capture this species, suggesting he may have overlooked its preferred microhabitat.

Localities and specimens: (Site 28) CAS 169877; (Site 35) CAS 125092.

***Typhlops castanotus* Wynn and Leviton**

Described very recently (Wynn and Leviton, 1993), this distinctive bicolored species is known from Negros, Panay (Makato), Boracay, and Inampulugan islands. It has been collected under debris in bamboo and coconut groves, hardwood forests and forest remnants.

Localities and specimens: (Site 3) CAS 139171; (Site 8) CAS 127973; (Site 42) CAS-SU 27934-46.

***Typhlops hypogius* Savage, *Typhlops luzonensis* Taylor, and *Typhlops ruber* Boettger**

Found in detritus under rotting logs, these snakes have been collected in forests and disturbed areas near forest from sea level to about 800 m (Alcala, 1986). Wynn and Leviton (1993) followed McDowell (1974) in referring Philippine *T. luzonensis* and *T. hypogius* to *T. ruber*. Recently, McDiarmid et al. (1999) asserted that *T. luzonensis* and *T. hypogius* should be recognized until more compelling evidence is presented that would suggest they are conspecific with *T. ruber*. We agree, noting that the type localities for *T. hypogius* (Cebu), *T. ruber* (Samar), and *T. luzonensis* (Luzon) are each located on separate Pleistocene aggregate island complexes that might be expected to support independent lineages of blind snakes. If this is so, and the Visayan islands contain a single distinct lineage in this species complex, the name *Typhlops hypogius* would most likely apply to specimens from Cebu, Negros, Panay, Masbate, and smaller, land-bridge islands.

Localities and specimens: (Site 18) CAS 127861.

Family Viperidae

***Tropidolaemus cf wagleri* (H. Boie in F. Boie) (Figs. 51, 52)**

This arboreal viper is common in forest bushes and small trees as well as mangroves (Taylor, 1922d; Leviton, 1964b; Alcala, 1986). The Mt. Madja-as specimen was found in a banana plantation at 800 m near primary forest. We find it unlikely that all SE Asian populations currently referred to *T. wagleri* will prove to be a single species. This is the first account of a specimen referable to this species from Panay.

Localities and specimens: (Site 11) CMNH 5076.

Discussion

The primary goal of this report has been to provide a comprehensive and synthetic review of the amphibian and reptiles species known from Panay Island and its surrounding land-bridge islets. As noted, over the past century, biologists have expected that the documented presence of a species on the neighboring island of Negros implied its undocumented presence on Panay as well (see Inger, 1954; Brown and Alcala, 1970, 1978, 1980, 1986; Brown and Rabor, 1967; Alcala, 1986). However, Panay (and its smaller satellite islets) supports low levels of endemism, primarily as exemplified by populations at higher montane elevations. Panay has several species of amphibians and reptiles that have not yet been reported on Negros or Cebu, is known to support species that so far have not been documented on Panay. The presence on Panay of numerous new and undescribed species suggests that calculations of Panay's herpetological endemism will continue to rise with continued survey work. Additionally, basic taxonomic studies of species complexes with representatives on Panay will no doubt further contribute to the total number of Panay endemics.

There are only a few reports of amphibians and reptiles of high elevation forests of Panay (Sison et al., 1995; W. Brown et al., 1997a; Ferner et al., 1997; R. Brown et al. 1999, this issue). Essentially, on each occasion that herpetologists have surveyed higher elevation forests of Panay, they have discovered new species. Other surveys conducted in forested regions of Panay include survey efforts of A. Diesmos, R. Crombie, and M. Gaulke (in press). Further high elevation surveys in well forested regions of Panay are greatly needed to gain an understanding and appreciation of these presumably relict faunal elements.

There are numerous records that are included in this report that were not at all unexpected. These include widespread SE Asian and Philippine species that biologists have expected or assumed were present on Panay. Others have even been listed as known from Panay, but without specific reference to reliable locality data or museum specimens (see Alcala, 1986). These include the frogs *Bufo marinus*, *Kaloula picta*, *Occidozyga laevis*, *Platymantis corrugatus*, *Platymantis dorsalis*, *Rana vittigera*, the skink *Mabuya multifasciata*, and the snakes *Ramphotyphlops braminus*, *Acrochordus granulatus*, *Psammodynastes pulverulentus*, *Gonyosoma oxycephala*, and *Tropidolaemus cf wagleri*.

Another group of species includes forms known from other well-surveyed islands in the Visayas



Fig. 3. Habitat at 1510 m elevation on the western slope of Mt. Madja-as (Site 11; Photo: RMB).



Fig. 4. Primary forest at approximately 1400 m on the western slope of Mt. Madja-as (Site 11; Photo: RMB).



Fig. 5. Stunted cloud forest at the peak of Mt. Madja-as (1800 m); habitat of *Platymantis panayensis* (Site 11; Photo: RMB).

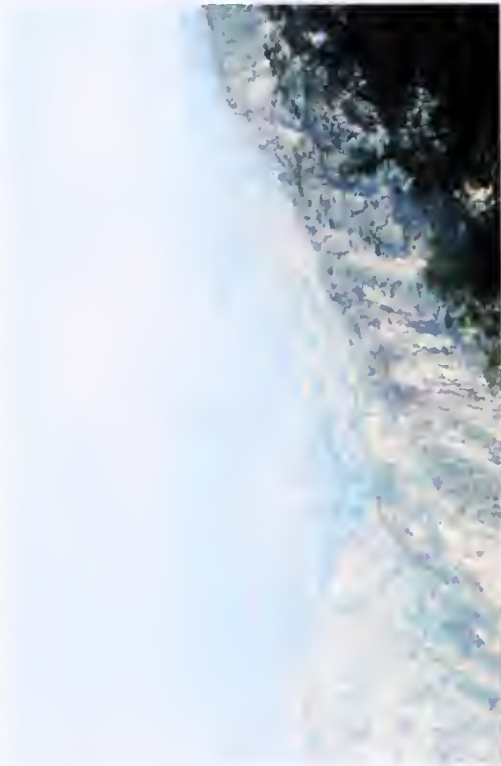


Fig. 6. Entirely deforested lower slopes (750 m and below) on the western face of Mt. Madja-as (Site 11; Photo: L. Ruedas).



Fig. 8. Barangay San Carlos at 400 m on Mt. Baloy (Site 13; Photo: J. McGuire).



Fig. 10. Gigante South Island, from a distance, in the Visayan sea (Photo: RMB).



Fig. 7. Deforested foothills of Mt. Baloy at Barangay Valderrama (Site 13; Photo: J. McGuire).



Fig. 9. The Cadian River near Valderrama at the base of Mt. Baloy (Site 13; Photo: J. McGuire).



Fig. 11. Flooded mangrove forest on northeast coast of Negros Island (Photo: RMB).



Fig. 12. South coast of Gigante North Island (Site 35; Photo: RMB).



Fig. 13. Limestone cave on Gigante South Island; habitat of *Gekko gigante* (Site 37; Photo: RMB).



Fig. 14. Jagged karst limestone habitat of *Platymantis insulatus* on Gigante South Island (Site 36; Photo: RMB).



Fig. 15. *Bufo marinus* (Photo: RMB).



Fig. 16. *Kaloula conjuncta negrosensis* (Photo: RMB).



Fig. 17. *Kaloula picta* (Photo: RMB).



Fig. 18. *Limnonectes cf. leytenensis* (Photo: RMB).



Fig. 19. *Limnonectes visayanus* (Photo: RMB).



Fig. 20. *Occidozyga laevis* (Photo: RMB).



Fig. 21. *Platymantis corrugatus* (Photo: RMB).



Fig. 22. *Platymantis insulatus* (Photo: RMB).



Fig. 23. *Rana erythraea* (Photo: RMB).



Fig. 24. *Rana vittigera* (Photo: RMB).



Fig. 25. *Polypedates leucomystax* (Photo: RMB).



Fig. 26. *Cuora amboinensis* (Photo: RMB).



Fig. 27. *Draco spiloater* (Photo: J. McGuire).



Fig. 28. *Draco spiloater* with extended patagium (Photo: J. McGuire).



Fig. 29. Mature female *Hydrosaurus pustulatus* (Site 23; Photo C. Banks).



Fig. 30. Immature female *Hydrosaurus pustulatus* (Site 11; Photo: J. McGuire).



Fig. 31. Mature male *Gonocephalus* sp (Photo: RMB).



Fig. 32. *Cyrtodactylus annulatus* (Photo: RMB).

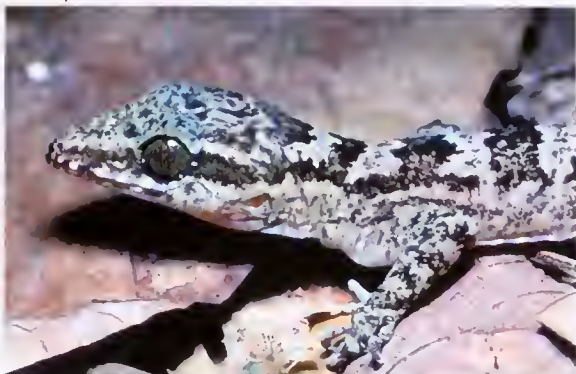


Fig. 33. *Cyrtodactylus philippinicus* (Photo: RMB).



Fig. 34. *Gehyra mutilata* (Photo: RMB).



Fig. 35. *Gekko gigante* (Site 37; Photo RMB).



Fig. 36. *Gekko gigante* eggs in cave crevice (Site 37; Photo: RMB).



Fig. 37. *Gekko mindorensis* (Photo: RMB).



Fig. 38. *Brachymeles boulengeritaylori* (Photo: RMB).



Fig. 39. *Brachymeles boulengeri taylori* (Photo: RMB).



Fig. 40. *Brachymeles tridactylus* (Photo: RMB).



Fig. 41. *Mabuya multicarinata borealis* (Photo: J. McGuire).



Fig. 42. *Sphenomorphus jagori grandis* (Photo: RMB).



Fig. 43. *Tropidophorus grayi* (Photo: RMB).



Fig. 44. *Varanus salvator nuchalis*, dorsal view (Photo: J. McGuire).



Fig. 45. *Varanus salvator nuchalis*, ventral view (Photo: J. McGuire).



Fig. 46. *Python reticulatus* (Photo: RMB).



Fig. 47. *Ahaetulla prasina preocularis* (Photo: RMB).

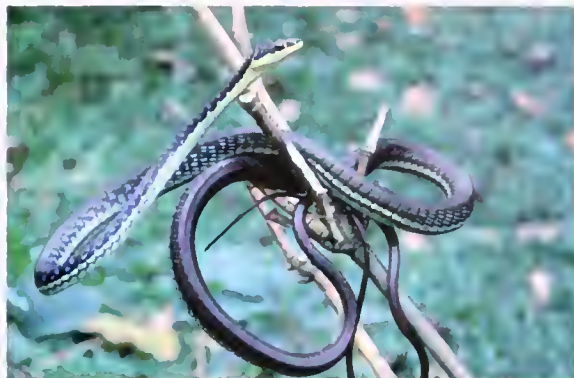


Fig. 48. *Dendrelaphis pictus pictus* (Photo: RMB).



Fig. 49. *Lycodon aulicus capucinus* (Photo: RMB).



Fig. 50. *Pseudorabdion mcnamarae* (Photo: RMB).



Fig. 51. Typical male *Tropidolaemus* cf *wagleri* (Photo: RMB).



Fig. 52. Typical female *Tropidolaemus* cf *wagleri* (Photo: RMB).

(Negros, Cebu) that we expected to find on Panay as well. Their presence on Panay was almost a certainty based on known biogeographic relationships of these islands. These species include the frogs *Kaloula c. negrosensis*, *Limnonectes cf. leytenensis*, the skinks *Lipinia pulchella taylori*, *Brachymeles boulengeri taylori*, *Mabuya multicarinata borealis*, *Tropidophorus grayi*, *Emoia atrocostata*, the geckos *Cyrtodactylus annulatus*, *Cyrtodactylus philippinicus*, the sail-fin agamid *Hydrosaurus pustulatus*, and the snakes *Boiga angulata*, *Boiga cf. cynodon*, *Boiga cf. dendrophilia*, *Cyclocorus lineatus alcalai*, *Pseudorabdion mcnamarae*, *Oligodon modestum*, and *Trimeresurus flavomaculatus* (Gaulke, in press).

Several other records are major range extensions and real surprises. The skink *Dasia semisincta* is otherwise known only from Borneo and Mindanao Island and its presence on Panay is based on a well vouchered specimen (USNM 78840) that can not be discounted. The presence of a new species in the genus *Hologerrhum* was surprising in that this genus previously was considered a monotypic Luzon Aggregate Island Complex endemic (Leviton, 1963c; Brown et al., this issue; Gaulke, in press). A forest species of *Kaloula* related to *K. kalingensis* and *K. kokacii* is the first record of this species group outside the boundaries of the Luzon Aggregate Island Complex (Inger, 1954; Brown and Alcalá, 1970; Alcalá and Brown, 1998; Brown and Diesmos, unpublished data; Gaulke, in press). Some records (based on few specimens or dubious locality data) may be in error; these include *Sphenomorphus coxi divergens*, *Sphenomorphus cumingi*, and *S. fasciatus* (of Sison et al., 1995); otherwise, if accurate, these records represent major range extensions beyond the confines of the Mindanao, Mindoro, and Luzon aggregate island platforms.

As mentioned, a number of new species recently have been described as Panay endemics; the presence of endemics in high elevation habitats of Panay was not unexpected. These species *Hologerrhum dermali* (Brown et al., this issue; see also Gaulke, in press), *Parvoscinus sisoni* (Ferner et al., 1997), *Platymantis panayensis* (Brown et al., 1997a), *Pseudorabdion talonuran* (Brown et al., 1999), *Kaloula* sp., *Platymantis* sp. 1, *Platymantis* sp. 2, and *Platymantis* sp. 3 (this report, see also Gaulke, in press).

Finally, there are numerous "subspecies", species, or members of widespread Visayan, Philippine, or SE Asian species complex members on Panay that are of uncertain taxonomic status and in need of basic taxonomic review (see individual species accounts). Many species currently listed from Panay are, we expect, distinct lineages that eventually will be recognized as

Panay or Visayan endemics. These species are too numerous to list and extend from common, low elevation forms to rare high elevation forest obligates. There is much basic taxonomic work still to be conducted on Panay, in the Visayas, and in the rest of the Philippines and we expect our estimates of Panay's endemicity to generally rise with further systematic studies of the herpetofauna of the Philippines.

Faunal similarity calculations (Fig. 53) indicated that, as expected, the Visayan islands of Negros and Cebu (situated on the same Pleistocene aggregate island platform as Panay) were among the islands faunistically most similar to Panay (Masbate was not considered due to the absence of substantial records from this island). We interpret this as evidence for mid- to late-Pleistocene land bridge connections between these islands (see Heaney, 1985, 1986). Within the Visayan Aggregate Island Complex, estimates of amphibian faunal similarities exceeded those of reptiles but when Panay is compared to islands outside the Visayan Aggregate Island Complex, reptile faunal similarities exceed those of amphibians. As expected, amphibian faunal similarity between Luzon and Panay is much lower than estimates calculated for Cebu or Negros and Panay. However, surprisingly, Luzon and Panay had a higher reptile coefficient of similarity than did Cebu and Panay. A portion of this unusual finding may be the result of sampling error reflecting the degree to which survey data for Negros, Panay, and Luzon are available. Calculations of similarities between Negros and Luzon (not shown) are higher in reptiles (0.58) than they are for amphibians (0.45).

In comparisons with islands on other (non-Visayan) major Philippine aggregate island platforms, reptilian species similarity was consistently higher than that of amphibians. This may in part be due to antiquated taxonomy. Recently, disproportionate amounts of taxonomic work has been conducted on amphibian groups, resulting in the recognition of more amphibian endemics, with fewer "shared" species among islands. In contrast, many reptiles "species" are shared between Panay and Luzon. Some of these may represent species complexes in need of taxonomic resolution. Alternatively, these calculations may reflect the relatively greater dispersal abilities presumed for reptiles when crossing ocean barriers. It is tempting to consider that more reptile species may be shared between these islands because reptiles may be more tolerant of exposure to heat and salt water, and may have a higher probability of surviving dispersal events (e.g., via rafting) than would be expected for amphibians. In general, these results sup-

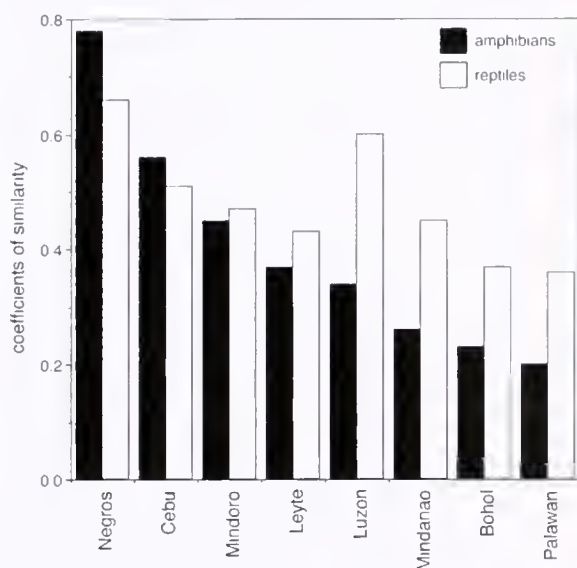


Figure 53. Faunal similarity coefficients, calculated between Panay and other major islands in the Philippines. See text for formula and discussion.

port the suggestion that the herpetofaunal communities of islands within the Visayan Aggregate Island Complex are very similar but also that they have their own degree of endemism and are far from being identical.

Species that we might expect to soon be discovered on Panay include populations that are otherwise known from Negros and Cebu islands. However, we note that the high elevation endemics of Negros (e.g., *Platymantis hazelae*, *Pseudorabdion montanum*) are not expected to be discovered on Panay; in their place we expect Panay to support its own high elevation populations of closely-related montane endemics (e.g., *Platymantis panayensis*, *Pseudorabdion talonuran*). These include the frogs *Rhacophorus pardalis* (Fig. 54), *Rhacophorus appendiculatus* (widespread on Mindanao and Luzon aggregate island complexes; both known from Negros), *Platymantis spelaeus* (known from Negros; Fig. 55), geckos such as *Lepidodactylus lugubris* (widespread in the Philippines), *Lepidodactylus herrei* (currently comprised of two subspecies: *L. h. herrei* on Negros and *L. h. medianus* on Cebu), *Lepidodactylus christiani* (known from Negros and Cebu), *Pseudogekko brevipes* (known from Negros and Cebu; *P. compressicarpus* has been collected on Masbate), a *Luperosaurus* species (*L. cumingi* has been collected on Negros), and skinks like *Lipinia quadrivittata quadrivittata* (from Negros and Cebu), *Lipinia auriculata auriculata* (from Negros and Masbate), and *Lipinia rabori* (from Negros). Snake species we expect will be found on

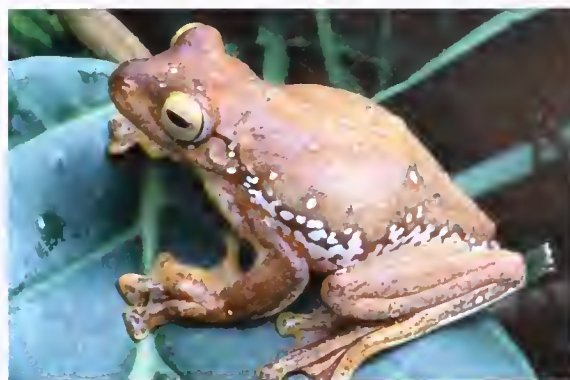


Fig. 54. *Rhacophorus pardalis*, present on Negros but not yet recorded on Panay (Photo: RMB).



Fig. 55. *Platymantis spelaeus*, known from caves in southern Negros; this species has not yet been recorded on Panay (Photo: RMB).



Fig. 56. *Oxyrhabdion leporinum visayanum*, well-known and common throughout Negros Island, but not yet recorded on Panay (Photo: RMB).

Panay with continued survey efforts include forms possibly related to *T. canlaonensis*, *T. hedraeus* (Negros forms), *Oxyrhabdion leporinum visayanum* (from Negros and Cebu; Fig. 56), and *Ophiophagus hannah* (recorded from numerous islands in the Philippines). The Philippine endemic crocodile, *Crocodylus mindorensis*, may have recently been rediscovered

on Negros (E. Alcala, personal communication) and may be present on Panay if suitable habitat can be located. As noted, the Gigante Island endemics *Platymantis insulatus* and *Gekko gigante* might be expected to occur on karst limestone outcrops on Panay's northeast coast.

The future of exploration on Panay guarantees continuation of the kind of discovery reported here. There is an immediate need for continued basic survey efforts in the montane portions of Antique, Aklan, and Iloilo provinces, all of which contribute to the western coastal mountain range that supports so much of Panay's herpetological endemicity. Additionally, low elevation portions of Panay (principally Capiz and Iloilo provinces) are also herpetologically unknown. If areas of overlooked primary forest or well-regenerated secondary forest can be located, we have high expectations that these will support novel herpetological communities and generate continued discoveries of new taxa. Areas of particular interest include karst limestone outcrops along the northern and eastern coasts, mangrove fragments, cave habitats, and isolated outcrops of moderate elevation in eastern Panay (Fig. 2). As noted, the best place to search for the Gigante endemics *Platymantis insulatus* and *Gekko gigante* is limestone outcrops supporting caves along Panay's northeastern coast. Other rare Negros species (i.e., *Luperosaurus cumingi*, *Lepidodactylus herrei*, *Platymantis spelaeus*) may eventually be revealed on Panay as well, once adequate surveys in preferred microhabitats (forest canopies and karst limestone caves; C. N. Dolino, personal communication) become available.

Like most islands in the Visayan Aggregate Island Complex, Panay should be regarded a priority for future conservation initiatives and programs aimed at sustainable resource management. Panay is a unique island (not at all identical to Negros) that deserves its own conservation efforts.

The few remaining forests of Panay continue to be felled at an alarming rate, suggesting that its endemic flora and fauna may disappear before even being recorded by biologists. Low elevation forests and mangroves are all but gone, and even the most disturbed and negatively impacted sites warrant immediate study of the kind that currently is underway on Cebu and Negros (A. Alcala, and E. Alcala, C. N. Dolino, J. C. Gonzales, and M. Pedregosa, personal communication). It is our hope that Panay will be recognized as a model island ecosystem, ripe for collaborative efforts of conservation biologists, taxonomists, biogeographers, community organizers, and politicians. Conservation efforts targeted at the community

level represent the best opportunity for foreign, government, and non-government organizations in their effort to halt the destructive practices of non-sustainable timber and mineral extraction industries that currently operate unchecked in the central Visayan islands of the Philippines.

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The Discovery of *Mauremys iversoni*-like Turtles at a Turtle Farm in Hainan Province, China: The Counterfeit Golden Coin

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Abstract.— During a visit to a turtle farm in Hainan Province, we discovered turtles that closely resemble *Mauremys iversoni*. The *Mauremys iversoni*-like turtles at the turtle farm were intentionally produced hybrids of two commonly reared species, *Mauremys mutica* and *Cuora trifasciata*. According to the turtle farmer, the intentional production of hybrids between these two turtles is a common practice. The hybrids fetch extremely high prices (~1000 USD/kg) since they are sold as *Cuora trifasciata*, the “golden coin” turtle, to unsuspecting buyers. We suggest, but cannot prove, that all *Mauremys iversoni*-like turtles might be turtle farm hybrids. This hypothesis could explain all of the available evidence and could alleviate a lot of the confusion surrounding this species unusual geographical distribution, sudden appearance in the pet trade, as well as its variable morphology.

Key words.— Turtles, Bataguridae, Geoemydidae, *Mauremys*, *Cuora trifasciata*, *Mauremys iversoni*, China, Hainan, hybrids, turtle farm

Introduction

Mauremys iversoni Pritchard and McCord 1991 is one of ten new Chinese chelonians described from specimens purchased through the pet trade since 1987. From the beginning, our knowledge of this species' geographical distribution has been fraught with confusion. The type specimen of *Mauremys iversoni* (UF 71866; institutional abbreviations follow Leviton et al., 1985) and 19 other individuals are reported to have come from Fujian province (Fig. 1a), but eight additional specimens from a locality in Guizhou (over 1000 km away) were also reported (Fig. 1b). Pritchard and McCord (1991) propose two hypotheses to explain this disjunct distribution: 1) The distribution is (or was) continuous between these localities; 2) One of the localities (perhaps the type locality) is the result of turtles being relocated by traveling Buddhists.

An additional wrinkle is provided by Iverson and McCord (1994) who suggest that the type series of *Mauremys* “*guangxiensis*” (=“*Clemmys guangxiensis*” Qin 1992) from Guangxi (Fig. 1c) is actually a composite of *Mauremys mutica* and *Mauremys iversoni*-like specimens. However, some differences between the *M.* “*guangxiensis*” *iversoni*-like specimens, the Guizhou *M. iversoni* specimens, and the Fujian *M. iversoni* specimens have been noted (Pritchard and McCord, 1991; Iverson and McCord, 1994). The result is the occurrence of different-looking *M. iversoni*-like turtles from three disparate

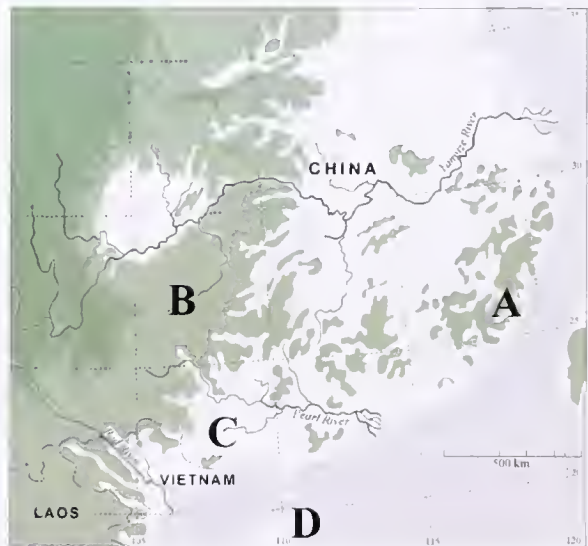


Figure 1. The reported localities of *Mauremys iversoni*-like turtles in China: A) Type locality, Nanping, Fujian Province (Pritchard and McCord, 1991); B) Kweiyang, Guizhou Province (Pritchard and McCord, 1991); C) Nanning, Guangxi Province (Qin, 1992); D) Tunchang, Hainan Province (This study).

regions in China between the years of 1986 and 1991 (Fig. 1). Based on observations from a breeding facility located on Hainan Island (Fig. 1d), we propose a third hypothesis that might explain all of the available data and possibly alleviate much of the confusion: All *Mauremys iversoni*-like turtles are the result of the



Figure 2. An intentionally produced hybrid from a Chinese turtle farm (MVZ 230475) that closely resembles *Mauremys iversoni*. Photo by JFP.

hybridization of *Mauremys mutica* and *Cuora trifasciata* in captivity.

Chinese turtle farms

The role of turtle farms in the Asian turtle trade is often overlooked. The primary reason for this is the secrecy of the turtle farmers themselves. Despite our ignorance, the practice of farming turtles in China is a widespread, lucrative endeavor. As far back as 1991, Zhou and Zhou report that *Cuora trifasciata* is being

bred "everywhere". In the past ten years, the number of turtle farms is rumored to have increased dramatically. Although it is not possible to provide exact numbers, there are estimated to be at least ten breeding facilities on Hainan alone. In an attempt to assess the impact of this burgeoning business to the Asian turtle trade, one of us (HS) has gained access to a large turtle farm in Tunchang, Hainan province (Fig. 1d) from 1996 to the present. This paper represents the second report of this effort (see also Shi and Parham, 2001).

According to the owner of the turtle farm, the Tunchang breeding facility was first established in 1983. The foundation of its breeding stock came from dozens of wild collected *Cuora trifasciata*, *Mauremys mutica*, and *Ocadia sinensis* from Hainan as well as additional specimens from a farm in Guangdong that was established in 1978. It currently houses an estimated 15,000+ geoemydids. Early on, the number of breeding ponds and turtles was limited and the establishment of breeding stocks proceeded without clear aim. Almost all the local species of turtles were collected from the field or bought from villagers and often kept in the same pond or enclosure.

In November of 1999, the authors visited a smaller facility that included several indoor breeding ponds.



Figure 3. A comparison of *Mauremys iversoni* plastra from the type description with turtle farm hybrids and putative parental species: A) *Mauremys mutica* from a turtle farm in Tunchang, Hainan Province (MVZ 230477); B-D) *Mauremys iversoni* from the type description. They are either from Fujian or Guizhou Province; E-F) Intentionally produced hybrids from a turtle farm in Tunchang, Hainan Province; G) *Mauremys iversoni* from the type description. It is either from Fujian or Guizhou Province; H) An intentionally produced hybrid from a turtle farm in Tunchang, Hainan Province (MVZ 130475); I) *Cuora trifasciata* from Tai Pin, central Hainan Province (MVZ 23932); J) *Cuora trifasciata* from the pet trade (MVZ 230636). Photos by JFP [a,e-f,h-j] and Pritchard and McCord (1991)[b-d,g].

Although numerous species were observed, *Mauremys mutica* and *Cuora trifasciata* were the most abundant. Many of the *C. trifasciata* were kept separately, but one pond included *C. trifasciata*, *M. mutica*, and even a *Chelydra serpentina*. When asked if any of the turtles ever hybridized, the workers of the farm produced several animals that closely resembled *Mauremys iversoni*. One of these hybrids, a subadult male, was procured as a voucher (MVZ 230475; Fig. 2, 3h). JFP was given permission to photograph two other hybrids (Fig. 3e,f).

The turtle farm hybrids

As with the three previously reported incidences of *M. iversoni* (Fujian, Guizhou, and Guangxi), there are some differences in the Hainan farm specimens. Unfortunately, it is difficult to understand these differences because of inconsistencies in the reporting of previous measurements, small sample sizes, and the fact the most important specimens remain in private hands. For example, Pritchard and McCord (1991) present bivariate plots of measurements for adult *Mauremys iversoni*, but inexplicably include only five of the adult males. It is not stated from which locality (Fujian or Guizhou) these specimens are from or why the measurements of all 10 of the adult males from Fujian (the type locality) are not included. Table 1 of Pritchard and McCord includes 10 shell measurements for all the specimens, but excludes the two measurements (the interpectoral length [IPL] and the interanal length [IAN]) that would have allowed the type series to be included in the bivariate plot. Iverson and McCord (1994) perform a more detailed study of variation within East Asian *Mauremys*, but do not present the raw data and only include one specimen of Guizhou *Mauremys iversoni* (no voucher).

The relevant shell measurements of MVZ 230475 are as follows: IAN= 1.4 cm, IPL= 1.1 cm, CL= 11.4 cm, IAN/CL= .1228, IPL/CL=.096. MVZ 230475 is a juvenile and smaller than three specimens excluded from the adult category by Pritchard and McCord (1991). Bearing this consideration, a comparison shows that the morphology of MVZ 230475 is unlike the type series of *Mauremys iversoni*, and apparently unlike the other *Mauremys*. It is uncertain what the variation between and among the *Mauremys iversoni* series (from Guizhou and Fujian) is fully represented by the polygon in Pritchard and McCord (1991). Since the relevant scale ratios from their entire series, including the subadult specimens, are not reported, we are forced to rely on the close phenetic similarity between the turtle farm hybrids and *M. iversoni* for our conclusions. It is important to emphasize that if



Figure 4. *Cuora trifasciata* from a Chinese turtle farm showing light head coloration. Photo by HS.

all *M. iversoni* are turtle farm hybrids, then we should expect them to have an extremely variable morphology, especially if they are the result of separate hybridogenic events. This pattern is borne out by the previously reported *M. iversoni*-like turtles (Pritchard and McCord, 1991; Qin, 1992; Iverson and McCord, 1994).

In terms of coloration, MVZ 230475 and the hybrids photographed at the Tunchang turtle farm closely resemble *Mauremys iversoni*. The head coloration of MVZ 230475 is lighter than that of the specimen figured by Pritchard and McCord (1991), but a variation in head coloration in *Mauremys iversoni* was noted by Fritz and Obst (1999). MVZ 230475 is almost identical to the lighter individual figured in that work. The variable head coloration in *M. iversoni* can be linked to the variation in *C. trifasciata*. For, while most *C. trifasciata* have dark postorbital markings, *C. trifasciata* with light head coloration are known (Fig. 4), especially in turtle farms. Pritchard and McCord (1991) state that *M. iversoni* can be distinguished from *M. mutica* by a horseshoe-shaped coalescence of blotches from the pectorals to the anals (with the open end anterior). Although they state that this pattern is not found in *Mauremys mutica*, Zhou and Zhou (1991, p. 38) illustrate a *M. mutica* (locality not stated) with this this plastral pattern. Later, Iverson and McCord (1994) illustrate a *M. mutica* from Taiwan (FMNH 127181) that also has a clear horseshoe-shaped coalescence of blotches. Even without this character, *M. iversoni* can be distinguished from *M. mutica* by its more rounded anterior lobe that lacks a prominent gular projection. Furthermore, many *M. iversoni* specimens, including some of the type series

of *M. iversoni* and the Hainan farm hybrids (Fig. 3b-f) have transverse trending blotches on the pectorals, a feature not known to occur in *Mauremys*, but common in juveniles of *C. trifasciata*.

The variation among the figured specimens in the type description is extreme (Fig. 3b-d,g). It is not stated whether these specimens are from Fujian or Guizhou. Comparisons of the plastral figures from Pritchard and McCord (1991) with the specimens from the Tunchang farm show that the latter specimens lie within the range of variation of *M. iversoni*. The most notable differences are that one (Fig. 3e) has more irregularly shaped plastral blotches and MVZ 230475 (Fig. 3h) has only a narrow, light, central figure on the plastron. Perhaps the most important feature to be noted is that no two specimens look alike. In the type description, Pritchard and McCord (1991) describe the plastral pigmentation as "very variable in intensity", but it is unclear whether the figured specimens represent the most typical patterns of *Mauremys iversoni* or the entire range of variation.

Luckily, there are three characters of *M. iversoni* that clearly set it apart from other East Asian *Mauremys*: 1) its olive or yellow head, 2) rounded end of anterior lobe of the plastron and 3) red coloration on the underside of the limbs. Until the description of *Mauremys iversoni*, the red coloration of the limbs was a diagnostic characteristic of *C. trifasciata*. The light head coloration and rounded lobe are also reminiscent of *C. trifasciata*. Furthermore, in *Mauremys iversoni* the sulcus between the humeral and abdominal scutes lies closer to the hyo/hypoplastral suture than it does in other *Mauremys*. An alignment of this sulcus with the junction of these bones is a character shared by *C. trifasciata* and other taxa with a kinetic plastron. In other words, the morphology of *Mauremys iversoni* is intermediate between *C. trifasciata* and *M. mutica*, and therefore consistent with a hybrid origin. A detailed comparison of the mitochondrial DNA and allozymes of this specimen and other pet trade "species" is currently under way (Parham et al., 2000; in prep.).

Discussion

During our joint visit to the Tunchang turtle farm, the workers stated that production of *Mauremys iversoni*-like turtles was the result of infrequent, accidental hybridization events. Since that time, the owner of the farm has confided that the intentional production of *C. trifasciata* X *M. mutica* hybrids is a common practice undertaken by several turtle farmers. Because practitioners of Chinese traditional medicine claim that *C. trifasciata* has many medicinal proper-

ties, and recently it has also been suggested that it has the ability to cure cancer, it is highly valued. As a result, it is often called the "golden coin" turtle. The price of turtles is determined by their weight. In the year 2000, 1 kg of *M. mutica* sold for approximately 100-120 yuan (~15 USD) whereas 1 kg of *C. trifasciata* sold for 6,000-8,000 yuan (~1000 USD). According to the turtle farmer, it is possible to sell the hybrids of *C. trifasciata* and *M. mutica* as pure *C. trifasciata* since, to the untrained eye, these species closely resemble one another, especially in the yellow coloration of the head. The confusion of these two forms should not be surprising since Timmins and Khounbolin (1999) report that even people familiar with *C. trifasciata* have mistakenly identified juvenile *M. mutica* as this species. Therefore, it is possible to produce and sell large numbers of counterfeit "golden coins" to unsuspecting buyers without having to obtain large numbers of adult *Cuora trifasciata*.

The high degree of phenetic similarity between the *C. trifasciata* X *M. mutica* hybrids from Hainan and the *M. iversoni*-like turtles reported from Fujian, Guizhou and Guangxi strongly suggests that all of these animals may be the product of accidental or intentional hybridization in turtle farms. This hypothesis explains the unusual morphology, its sudden appearance in the pet trade, absence in historical collections, and the confusion surrounding the distribution of this taxon. The timing of the discovery of these turtles shortly follows the increased demand for *Cuora trifasciata* as a reputed cure for cancer (van Dijk et al., 2000). This increased demand may have initiated the establishment of numerous turtle breeding facilities that led to the production of *Mauremys iversoni*-like turtles.

We stress that the practice of housing and breeding several species of chelonians in a single enclosure or pond is probably not restricted to the Tunchang farm alone. If the establishment of other facilities mirrors the one on Hainan, the sudden appearance of new and unusual turtles in the pet trade would be expected. The ability of turtles to hybridize is well documented (Fritz and Baur, 1994; Fritz, 1995). Certain species, such as *Mauremys pritchardi* McCord 1997, have already been implicated as possible hybrids (Artnier et al., 1998). Others, such as *Sacalia pseudocellata* Iverson and McCord 1992, *Ocadia glyphistoma* McCord and Iverson 1994, and *Ocadia phillipeni* McCord and Iverson 1992 are known from a paltry number of specimens which might be indicative of an accidental production in a turtle farm (van Dijk, 2000; Lau and Shi, 2000). It is probably not a coincidence that many of the newly described species (*O. phil-*

lipeni, *S. pseudocellata*, and *M. iversoni*) can be distinguished from their congeners by characters found in the commonly reared and highly valued *C. trifasciata*. Studies of the DNA of the holotypes of these species, compared with multiple, field-collected, vouchered specimens of established species from known localities, could easily determine the validity of these taxa.

Conclusions

It is uncertain whether all of the reported collection data from the pet trade, such as the distributional data for *Mauremys iversoni* are actual or fabricated. The rest of the available evidence strongly suggests, but does not prove, that all *M. iversoni*-like turtles could have a turtle farm origin. Parham and Li (1999) openly question the Yunnan locality of *Cuora pani* that was provided by the same pet dealer credited with collecting the original *Mauremys iversoni* series. The high prices that unusual turtles with locality data can fetch from turtle fanciers could serve as incentive to fabricate collection data. Furthermore, there is also incentive to hide the true locality as a trade secret, especially if the locality is a Chinese turtle farm. Of course, given the current scarcity of turtles in Asia it is difficult to prove that a locality is in error or whether the turtles have been extirpated. Verified distribution data for rare chelonians (e.g., Iverson, 1992) are critical to understanding their current and historical status. False localities unnecessarily complicate our meager understanding of turtle distributions. In light of the confusion surrounding pet trade data, we recommend that workers should treat them with utmost caution until they are supported by evidence that is more reliable.

Given the seemingly uncontrollable Asian Turtle Crisis, determining which species are valid evolutionary lineages and which are turtle farm hybrids is important. Otherwise, crucial resources could be wasted on invalid taxa. For example, the Red data Book of Endangered Animals (Wang, 1998) suggests that Fujian and Guizhou provinces protect *M. iversoni* and that surveys and ecological studies should be performed in order to determine the proper conservation strategies. We concur with van Dijk's (2000) assertion that researchers should make the investigations on the validity of the pet trade species a priority so that the limited resources for conservation can be directed towards established taxa that are undergoing unimagined, precipitous declines.

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A Review of the Distribution of Diploid, Triploid and Tetraploid Green Toads (*Bufo viridis* Complex) in Asia Including New Data from Iran and Pakistan¹

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Abstract.— A summary of the distribution of green toads containing most of the data published after the discovery of polyploid forms (1976) including a map, an index and a bibliography are presented and discussed. 21 Asian type localities of hitherto described nominal green toad taxa are shown. The tetraploids are distributed in high mountains and extremely continental regions with strong climatic shifts. Records of triploid specimens are situated in supposed contact zones between the parapatric diploid and tetraploid toads at foothills of Middle Asian high mountains, and triploid bisexual populations occur in the Karakoram and West-Himalayas. Habitats of diploids appear to be restricted to lowlands and valley grounds. Polyploids seem to be more resistant. The methods hitherto used for the determination of the ploidy level and their applicability are evaluated. We show new data on this species complex from Iran including cytometric, karyological, bioacoustic and morphological data and we draw taxonomic conclusions for tetraploid *Bufo oblongus*, diploid *Bufo viridis kermanensis*, and probably diploid *Bufo kavirensis*. New information on the distribution of triploids in northwestern Pakistan based on flow cytometric measurements is presented. The ploidy level of *Bufo latastii* is revealed to be diploid.

Key words.— Amphibia, Bufonidae, *Bufo viridis* complex, *Bufo oblongus* lectotype, *Bufo viridis kermanensis*, *Bufo kavirensis*, *Bufo latastii*, *Bufo pseudoraddei pseudoraddei*, *Bufo pseudoraddei baturae*, distribution, type localities, Asia, Iran, Pakistan, chromosomes, ploidy determination, calls, systematics

¹This paper is a chapter of the doctoral dissertation of M. Stöck.

Introduction

Since the discovery of tetraploid forms of the *Bufo viridis* complex in the northern Tien Shan (Bachmann et al., 1978; Mazik et al., 1976) many records of diploid, triploid and tetraploid green toads have been made, especially on the territory of the former Soviet Union and some few in other countries. New findings as the detection of possibly all-triploid, gonochoristic populations of this complex in the Karakorum range of Pakistan (Stöck et al., 1998, 1999) provide arguments that the number of investigations in this species complex will increase during the next years because not only zoogeographic and phylogenetic but also cytogenetic, bioacoustic and biochemical questions will be studied. Since a fundamental summary of the data on the territory of the former Soviet Union was done by Borkin et al. (1986a), the development of knowledge in this species complex has been dramatically increased.

Hence, the present paper was aimed to summarize the recent information about the distribution which is one of the preconditions for the understanding of the natural history of these toads. The data on chorology will also be an important prerequisite for a revision of systematics and nomenclature in this species complex.

We discuss the hitherto applied techniques of ploidy determination, the size of the (known) range of polyploid green toads, any detectable correlation of their occurrence with climatic/ecological factors, and we try to enlarge the knowledge about the ploidy level of taxa hitherto described from various type localities.

Because the knowledge on the ploidy of green toads from the territory of Iran and Pakistan is very scarce, we also present and discuss some new, sporadically collected data from different sources, and first results of a field excursion to Pakistan.

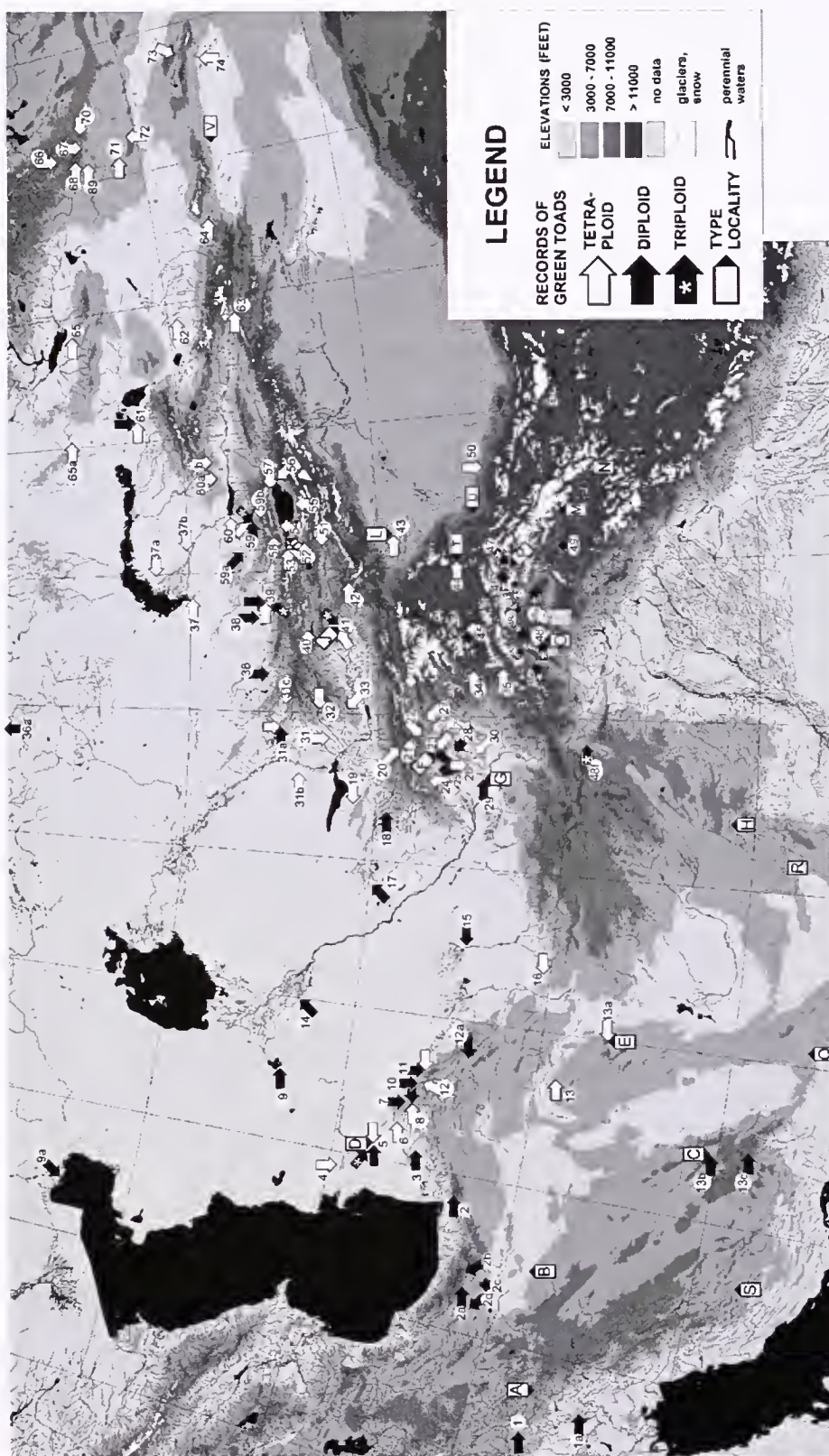


Figure 1. Map of Middle and Central Asia and parts of the Middle East with records of diploid, triploid and tetraploid green toads after 1976. For code numbers see appendix.

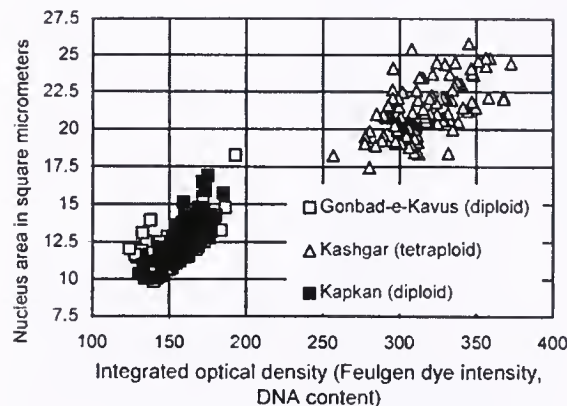


Figure 2. Diagram showing the nucleus projection area in relationship to the integrated optical density (the DNA content, respectively) of 100 Feulgen stained erythrocyte nuclei of a diploid standard specimen from 50 km E Gonbad-e-Kavus (3 in Fig. 1), a tetraploid standard specimen from Kashgar (43) and the diploid specimen from Kapkan (12a).

Material and Methods

New data from Iran

We used three sources: Martens (unpubl.) recorded mating calls of green toads from Fasham (4 July 1978, 23.00) and Polur (30 June 1978, 22.30) which were analyzed according to Stöck (1998a). Frynta collected in 1997 and 1998 (comp. Frynta et al., 1997) green toads, among them five living specimens from Gholaman (MTKD D 41350), Kapkan (MTKD D 41351), Baghestan (CUP AMPH/IRA/130) and Choqua Zambil (MTKD D 41352, 41353) whose ploidy levels were analyzed with erythrocyte measurements, microdensitometrical DNA-measurements and/or karyological techniques (Schmid, 1978; Stöck and Grosse, 1997a). Stöck visited in June 1998 Kerman, the type locality of *Bufo viridis kermanensis* Eiselt & Schmidtler, 1971, and Birjand, the type locality of *Bufo oblongus* Nikolsky, 1896. A mating call of a single male from Birjand recorded by Stöck in the late phase of the breeding period (8 June 1998, 21.30) was analyzed as described by Stöck (1998a). Seven specimens from Kerman (among them ZFMK 69909 to 69911, MTKD D 40730, 40731, 41348, 41349) and five adult and six juvenile specimens from Birjand (among them ZFMK 69901 to 69908, MTKD D 40729, 41346, 41347) were examined either by flow cytometry as described by Stöck et al. (1999) or karyologically according to Schmid (1978). For morphological comparisons we included type material - *Bufo kavirensis*: GNM Ba. ex. 1278 (holotype), GNM Ba.

ex. 1280 (paratype); *B. luristanicus*: ZMUC R 13221 (holotype); *B. oblongus*: ZISP 1952.1 (now lectotype), ZISP 1952.2 (now paralectotype). Institutional abbreviations are as listed in Leviton et al. (1985); for localities see Fig. 1.

New data from Pakistan

In June and July 2000, Stöck and Dressel traveled in the Northern Areas and North West Frontier Province of Pakistan. In the Hunza valley of the Karakoram Range near Karimabad ($n = 8$), and Pasu ($n = 50$), at the tributaries of the Gilgit river near Gupis ($n = 2$), at the Shandur pass ($n = 8$), and in the Chitral valley, near Buni ($n = 2$) and in Chitral City ($n = 8$), blood samples for ploidy determination of anesthetized adult green toads were taken, stored in 70% ethanol and refrigerated until flow cytometry according to Stöck et al. (1999).

In Skardu, at the western margin of the type region ("Ladak") of *Bufo latastii* Boulenger, 1882, blood samples of 15 adult toads of this species were taken, among them ZMB 62721 to 62726. A mating call of a single male (24 June 2000, 21.30) was recorded and analysed as described (Stöck 1998a).

For morphological comparisons we examined the lectotype of *Bufo latastii* BMNH 1947.2.21.28 (formerly 72.4.17.223; Stöck et al., 1999; Fig. 1).

Map (Fig. 1), list of records with ploidy detection and type localities of nominal Asian green toad taxa (Appendix)

The map contains most of the localities or regions where diploid, tetraploid and/or triploid toads have been recorded in Middle and Central Asia and the eastern parts of the Middle East after 1976, the year of the first detection of polyploids. Our map covers all regions where polyploid green toads have been found. These records (numbers 1 to 74) from the literature have been made using various methods for identification or determination of the taxa and/or ploidy levels. Some methods are not unambiguous and might therefore cause errors. Consequently, it was necessary to evaluate the methods which were utilized for the determination of the ploidy level because not all data are indisputable. In the case of the numbers 1 to 74, the present article only includes papers if they either contain statements on the ploidy of the toads or data appearing suitable to draw a conclusion to the ploidy (e.g. call data, see below). However, even if authors distinguished between diploid and tetraploid toads, in rare cases, especially in abstracts, the localities of the records were not precisely published (e.g., Fikhtman, 1989) or it was impossible to deduce from the publi-

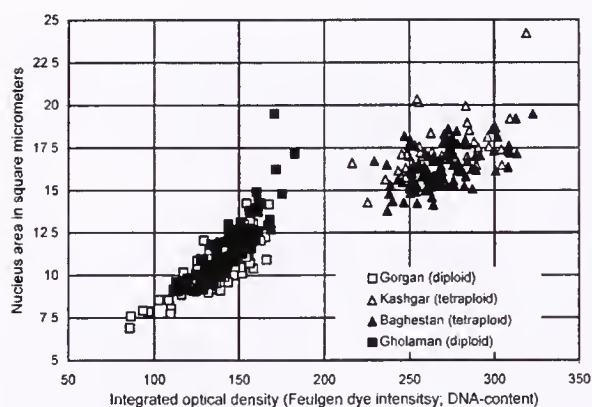


Figure 3. Diagram showing the nucleus projection area in relationship to the integrated optical density (the DNA content, respectively) of 100 Feulgen stained erythrocyte nuclei of a diploid standard specimen from S of Gorgan (2), 50 nuclei of a tetraploid standard specimen from Kashgar (43), 100 nuclei of the tetraploid specimen from Baghestan (13) and 100 nuclei of the diploid specimen from Gholaman (1).

cation to the exact ploidy of toads from a concrete locality (e.g., Castellano and Giacoma, 1998) and/or the method of ploidy determination was not mentioned (e.g., Pisanets & Vasilenko, 1995). Since no polyploid green toads have been found in the Caucasus (e.g., Kuzmin 1995: 187), we disregarded this area. If the information about a region but not a special position was available, the record is not shown in the map but listed in the appendix, and marked with a "?" (instead a number) in the line next to the nearest concrete record. Furthermore, we present some hitherto unpublished single records ("Stöck, unpubl.") from Kazakhstan and Kyrgyzstan.

We used different maps (Anonymous, 1993; DMAAC) and/or the descriptions and sketch maps in the literature (e.g., Borkin et al., 1986a) for the localization of the records. If they were available, the appendix contains the condensed descriptions of the localities, the geographic position and the method of ploidy determination.

The second part of the appendix (letters A to V) contains the 21 Asian type localities shown in Fig. 1 and represents a preliminary precondition for a systematic discussion. The bibliography in that part only comprises a choice of the literature which either discussed the systematic rank of a taxon or shows details suitable to draw a conclusion to the ploidy. Some descriptions of taxa either mentioned regions only but no special type locality (e.g., Boulenger, 1882: "Ladak" for *B. latastii*), but were drawn in the map; others presented a confusing diversity of type locali-

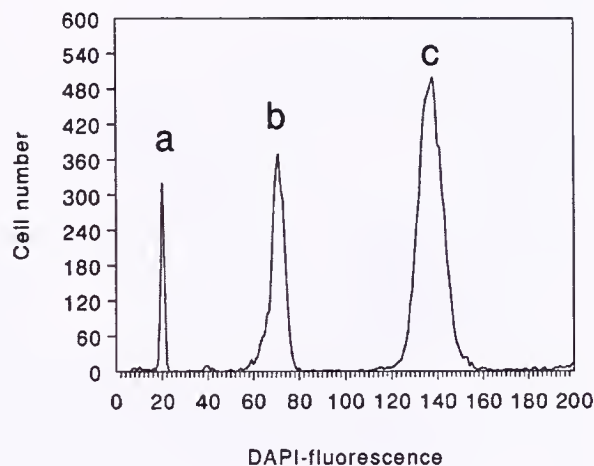


Figure 4. Histogram obtained by DNA flow cytometry from a mixture of DAPI stained blood samples with chicken as the standard (a), CV = 2.63%, a diploid green toad from Kerman, type locality of *Bufo viridis kermanensis*, (b), CV = 3.62%, and a tetraploid green toad from Birjand, type locality of *Bufo oblongus*, (c), CV = 3.31%. Total cell number 10 327.

ties covering large parts of Central Asia (e.g., Bedriaga, 1898: *B. viridis* var. *pewzowi* and var. *strauchi* with a type series from 4 or 14 localities, respectively, distributed from Mongolia to the Pamirs). In the latter cases, only some localities are shown, and this is mentioned in the appendix. In future, such taxonomic problems should be resolved by careful lectotype designations leading to type locality restrictions as a basis of a revision. Finally, the status of some old names, at least for diploid green toads, still remains unclear (see ref. in Kuzmin, 1999: 251, 264). They were not shown in the map or originated from regions outside of it.

Results and Discussion

New data from Iran

Cytometric and karyological data. A large male from Kapkan (Fig. 1: 12a) in the East-Iranian part of the Kopet Dag which we considered to represent *Bufo viridis turanensis* was identified to be diploid (Fig. 2). A male *Bufo viridis* ssp. from Gholaman (Fig. 1: 1; Fig. 8C) in the Zagros mountains, was diploid (Fig. 3); two additional males from Choqa Zanbil (Fig. 1: 1a) below the south-western foot of the Zagros mountains were also diploid.

All toads examined from Kerman, the type locality of *Bufo viridis kermanensis*, were found to be diploid as well (Fig. 4). This agrees with the contemporaneously published results of Borkin et al. (2000). We detected (Fig. 3) the first tetraploid toad in

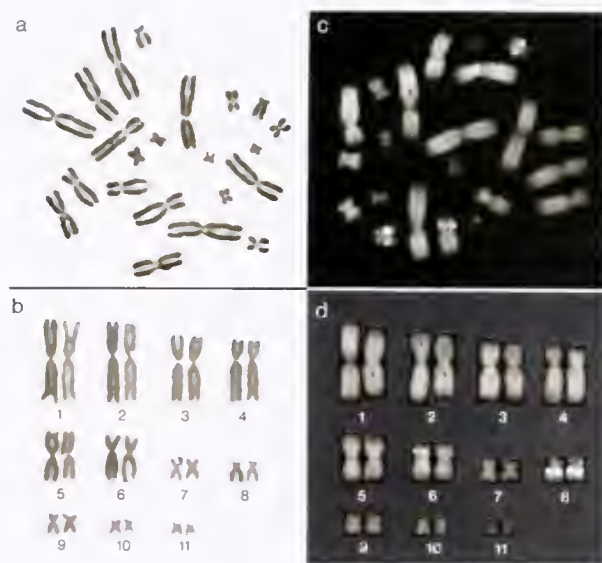


Figure 5. Chromosomes of diploid male *Bufo viridis kermanensis* from Kerman: a - Giemsa-stained metaphase, b - Giemsa-stained karyotype, c - Q-banded metaphase, d - Q-banded karyotype.

Iran near Baghestan (Fig. 1: 13; Fig. 8F) in the mountainous region north-eastern of the Central Iranian Plateau (abstract by Stöck et al., 1998). A sample of five toads from Birjand (Fig. 1: 13a), the type locality (Fig. 1: E) of *Bufo oblongus*, was found to be tetraploid (Fig. 4). Table 1 outlines the results of the flow cytometric measurements in specimens from Kerman and Birjand. Table 2 summarizes the results of erythrocyte size measurements. The erythrocyte sizes were typical of diploid and tetraploid green toads, respectively, according to Stöck and Grosse (1997a). The mean DNA content of *B. oblongus* (17.02 pg) rather corresponds to that of tetraploids from Kashgar (17.5 pg; Stöck, 1998b) measured with the same technique, but during another session.

The Giemsa-staining (Fig. 5a, b) revealed a diploid karyotype of *B. viridis kermanensis*. These conventionally stained chromosomes possess the characters of those from some other Eurasian diploid *Bufo viridis* which have been examined until now (Birstein, 1981; Bogart, 1972; Roth and Ráb, 1987; Schmid, 1978; Ullerich, 1966). The pair 6 terminally exhibits in its long arms a secondary constriction which is caused by the telomeric position of the nucleolus organizer regions (NORs) in *B. viridis* (see also Roth and Ráb, 1987; Schmid 1978). The Quinacrine-banding in chromosomes of *B. viridis kermanensis* (Fig. 5c, d) shows differently intensive fluorescing chromosomal regions in pairs 6 to 11, but distinct bright fluorescence



Figure 6. Chromosomes of a tetraploid female *Bufo oblongus* from Birjand. a - Giemsa-stained metaphase, b - Giemsa-stained karyotype, c - Q-banded metaphase, d - Q-banded karyotype.

was only found in short and long arms of pairs 6 and 8. Birstein (1981) detected Q-bands in a *B. viridis* from the Crimea in pairs 6 to 11 (the most distinct ones in both arms of pairs 7, 10, and 11). In a triploid taxon (*Bufo pseudoraddei baturae*) of the *B. viridis* complex from the Karakoram, we found Q-bands in the long arms close to the centromere of triplet 1, in the short arms of triplets 6 and 7 and in both arms of triplets 8 to 11 (Stöck et al., 1999).

Similarly, the karyotype of the tetraploid *Bufo oblongus* exhibits Q-bands in chromosomes of the quartets 1, 6 to 11 (Fig. 6c, d). The most interesting finding is the occurrence of Q-bands in the short arms of only two out of the chromosomes of quartet 6. These two chromosomes have also larger long arms than the two remaining Q-negative chromosomes, and therefore, we conclude that the Q-positive pair also represents the only one which carries the telomeric NORs as Roth and Ráb (1987) found in tetraploid toads from Kyrgyzstan. We are preparing a detailed cytogenetic study. Like in the triplet 1 of triploids from Karakoram, one or two chromosomes of quartet 1 in *B. oblongus* possess Q-bands in their long arms. Furthermore, additional differences are visible in the occurrence and position of Q-bands among the chromosomes in each of the quartets 7, 8 and 10 (Fig. 6c, d). These observations in *B. oblongus* provide arguments for considering this tetraploid form allopolyploid. The question of autopolyploidy or allopolyploidy of polyploids from various

Table 1. DNA content in diploid toads from Kerman (*Bufo viridis kermanensis*), diploid toads from Choqua Zanbil (*B. viridis* ssp.), tetraploid toads from Birjand (*Bufo oblongus*), and diploid *B. latastii* from Skardu measured by flow cytometry of DAPI stained erythrocytes with chicken nuclei (= 2.34 pg DNA/nucleus) as a standard. SD = standard deviation.

	Kerman, diploid (N = 7)			C. Zanbil, diploid (N = 2)			Birjand, tetraploid (N = 5)			Skardu, diploid (N = 15)		
	Ratio to chicken standard (= 1)	Ratio to Mean (%)	Absolute DNA content (pg)	Ratio to chicken standard (= 1)	Ratio to Mean (%)	Absolute DNA content (pg)	Ratio to chicken standard (= 1)	Ratio to Mean (%)	Absolute DNA content (pg)	Ratio to chicken standard (= 1)	Ratio to Mean (%)	Absolute DNA content (pg)
Mean	3.43	100	8.02	3.59	100	8.42	7.27	100	17.02	4.13	100	9.68
Min	3.25	94.75	7.61	3.56	99.04	8.34	7.04	96.83	16.47	3.77	91.21	8.83
Max	3.69	107.58	8.63	3.63	100.95	8.50	7.57	104.13	17.71	4.59	110.95	10.74
SD	0.17	-	0.40	0.05	-	0.11	0.19	-	0.45	0.25	-	0.27

Table 2. Erythrocyte size (projection areas of 30 red blood cells per toad were measured) in five tetraploid specimens from Birjand (*B. oblongus*), a tetraploid specimen from Baghestan, six diploid specimens from Kerman (*B. viridis kermanensis*), a diploid specimen from Kapkan, a diploid specimen from Gholaman, and two diploid specimens from Choqua Zanbil.

Parameter (μm^2)	Locality (ploidy)	Birjand (4n = 44) N = 5	Baghestan (4n = 44) N = 1	Kerman (2n = 22) N = 6	Kapkan (2n = 22) N = 1	Gholaman (2n = 22) N = 1	C. Zanbil (2n = 22) N = 2
Mean of means in the population		353.87	335.98	256.38	272.24	248.39	236.26
Maximal mean in the population		374.30	335.98	274.93	272.24	248.39	181.47
Minimal mean in the population		333.03	335.98	224.40	272.24	248.39	286.32
Largest cell measured		463.29	413.50	358.91	318.11	322.77	181.47
Smallest cell measured		274.07	280.11	183.95	216.37	216.21	286.32
Mean standard deviation in the pop.		33.62	30.80	23.22	21.99	22.17	22.94

localities has been controversially discussed (for overview see Balleto et al., 1999; Stöck et al., 1999). As compared with conventionally stained tetraploid karyotypes (e.g., Borkin et al., 1986b, c; Borkin and Kuzmin, 1988; Orlova & Uteshev, 1986; Pisanets, 1978; Roth & Ráb, 1986, 1987; Stöck, 1998b; Toktosunov, 1984; Whu & Zhao, 1987), that of *B. oblongus* (Fig. 6a, b) does not exhibit visible differences.

Mating calls (Fig. 7, Table 3). The mating call data from Lar valley (Andrén and Nilson, 1979), Fasham and Polur suggest that these toads are probably diploid (see below for methodical questions). The same prediction (Stöck, 1998a) is possible for the toads from Cheshmeh-ye-Sefid-Ab, the type locality of *Bufo kaviensis*. The mating call data from Polur (2a) and Fasham (2b) and the data from Lar valley (2b) and Gorgan (2) refer to the occurrence of (only) diploid

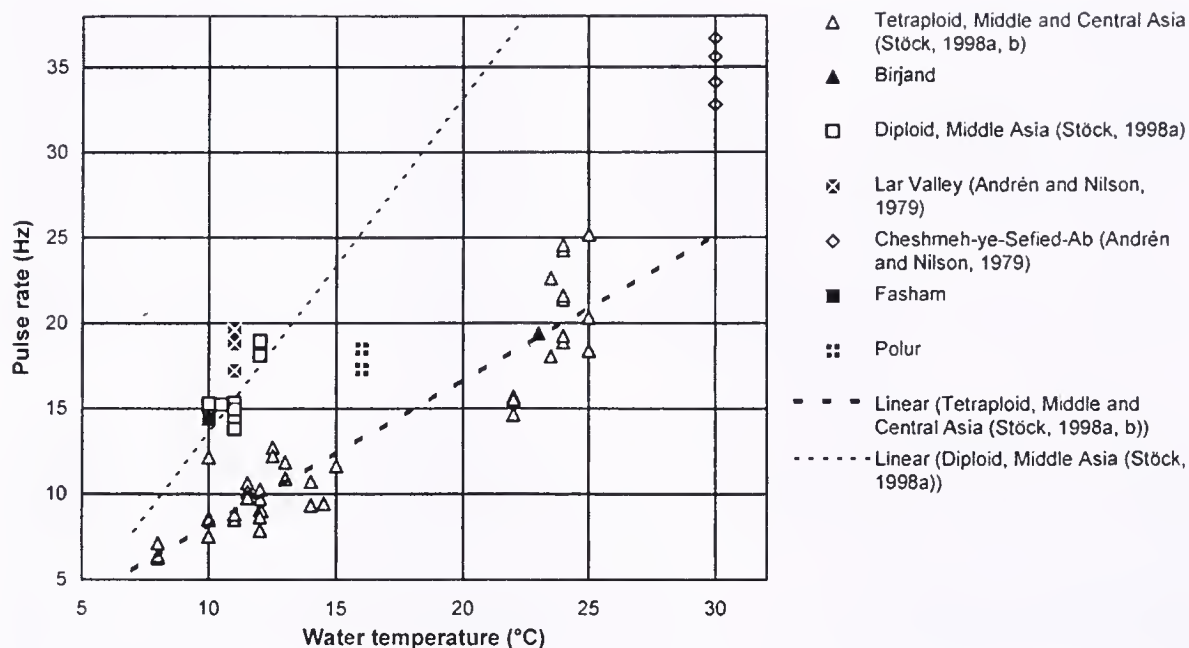


Figure 7. Pulse rate of mating calls of green toads from Iran in comparison with pulse rate of diploid and tetraploid toads from Middle and Central Asia. Birjand: type locality of *Bufo oblongus* Nikolsky, 1896. Toads from Birjand were found to be tetraploid (Fig. 4). Cheshmeh-ye-Sefid-Ab: type locality of *Bufo kavirensis*, Andrén and Nilson, 1979: the call data appear to elucidate that the taxon is diploid. Call data from Lar valley (Andrén and Nilson, 1979), Fasham and Polur (present study) provide arguments that these toads are diploid.

green toads in the Elburz mountains and confirm the evolutionary conservatism of the mating calls (disc. in Stöck, 1998b; Stöck et al., 1999). The single mating call of a tetraploid male (13a) from the type locality, Birjand (E), of *Bufo oblongus* confirmed previous data on tetraploids from various regions of Middle and Central Asia (Castellano et al., 1998; Stöck, 1998a, b).

Morphology and Taxonomy (Fig. 8). Although the locality (1) is relatively close to the type locality (A) of *Bufo luristanicus* (Schmidt, 1952), the morphology of the toads from Gholaman (Fig. 8C) and Choqa Zanbil differs completely from that of the *B. luristanicus* holotype (Fig. 8H). This confirmed once more the occurrence of at least two different green toad taxa in the north-western Zagros mountains of Iran as already Schmidtler and Schmidtler (1969) as well as Eiselt and Schmidtler (1973) stated. First, the form which was previously (Schmidtler and Schmidtler, 1969; Mertens, 1971b; Eiselt and Schmidtler, 1973) called *B. viridis arabicus* and to which the diploid toads from Gholaman and Choqa Zanbil belong to. Now, the name "arabicus" is no longer applicable since Balletto et al. (1985) restricted it to *B. arabicus* Heyden, 1827 from the Arabian Peninsula. Therefore, we preliminarily use the term *Bufo viridis* ssp. for them. The second taxon occurring in the north-western Zagros

mountains until eastern Iraq (Afrasiab and Ali, 1988) is *B. (surdus) luristanicus*. As to be seen in the appendix, the ploidy level of all three subspecies of *B. surdus* distinguished by Schmidtler and Schmidtler (1969) and Eiselt and Schmidtler (1973) is still unknown (cp. Baloutch and Kami, 1995).

The seven topotypic specimens of *Bufo viridis kermanensis* from Kerman (13b) are very similar to the holotype (NMW 19647) shown and described by Eiselt & Schmidtler (1971, 1973). This diploid form is different from the large sized diploid *B. viridis turanensis* as already Hemmer et al. (1978) stated and which was confirmed by our data.

The diagnostic differences between *Bufo kavirensis* and *B. viridis kermanensis* consist according to Andrén and Nilson (1979) in only two morphometric traits (I: ratio "distance between posterior border of nostril and anterior corner of eye/internal distance" 0.80 - 1.06 in *B. kavirensis* and 1.21 - 1.55 in *B. v. kermanensis*; II: ratio "width of upper eyelid / interorbital distance" 1.11 - 1.61 in *B. kavirensis* and 1.51 - 2.00 in *B. v. kermanensis*). Both ratios were not confirmed because the first ranged for our seven *B. viridis kermanensis* from 0.9 - 1.18 (and 0.93 - 1.05 in two specimens, Fig. 1: 13c, by Borkin et al., 2000); the second ratio varied also strongly from 0.8 - 2.92 (and 1.83 -

2.31, Borkin et al., 2000). Including the data shown above, we preliminarily consider (diploid) *B. kavirensis* to be a junior synonym of diploid *B. viridis kermanensis*. This also agrees with the range presumed by Eiselt and Schmidtler (1973) for their taxon. The relationships between diploid *B. viridis kermanensis* and diploid *B. viridis* ssp. (previously called *B. viridis arabicus*, see above) require additional investigations.

The morphological differences between *Bufo oblongus* (Fig. 8A, B, D) and *B. viridis kermanensis* (Fig. 8E) which were considered to be "very sharp

regarding neighboring races" (Eiselt and Schmidtler, 1973) were now explained by the different ploidy levels. The females of *B. oblongus* (e.g., Fig. 8B) examined from Birjand exhibited a coloration pattern which is very similar to that of the specimen ZISP 1952.1 from the type series (Fig. 8A). We therefore designate it here as the lectotype of *B. oblongus*, Nikolsky, 1896, and we consider this taxon according to the topotypes to be tetraploid. This demonstration of tetraploidy for *B. oblongus* is important for the taxonomy of green toads in Asia because the name is

Table 3. Mating call data of green toads from different regions of Iran. 50 km E Gonbad-e-Kavus, Lar valley, Polur, Fasham: *Bufo viridis* - probably diploid; Cheshmeh-ye-Sefid-Ab: *Bufo kavirensis* - probably diploid. Birjand: *Bufo oblongus* - tetraploid.

Locality (code in Fig. 1)	Male	AirT (°C)	WaterT (°C)	Interpulse interval (ms)	Pulse duration (ms)	Pulse rate (s ⁻¹)	Fundamental frequency (Hz)	Call duration (s) [N of calls measured]	Intercall interval (s) [N of intervals measured]	Source
50 km E Gonbad-e-	1	12.5	16.0	22.0	24.0	21.7	1349	-	-	Stöck (1998a)
Kavus	2	12.5	16.0	20.5	28.4	20.44	-	-	-	Stöck (1998a)
Lar valley	3	?	11	-	-	18.8	1200	4.16 [1]	-	Andrén and Nilson (1979)
(2b)	4	?	11	-	-	17.2	1400	4.43 [2]	-	Andrén and Nilson (1979)
	5	?	11	-	-	19.6	1325	4.8 - 5.4 [2]	-	Andrén and Nilson (1979)
Polur (2b)	6	16	14	26.5	27.4	18.5	1291	2.7 - 3.1 [3]	4.6 - 6.3 [2]	present paper
	6	16	14	30.7	27.1	17.3	1291	2.4 - 3.2 [5]	2.6 - 6.0 [4]	present paper
Fasham (2a)	7	14	10	34.5	34.9	14.4	1076	2.9 - 6.2 [4]	6.9 - 10.1 [3]	present paper
Cheshmeh-	8	-	30	-	-	36.7	1175	1.26 [2]	-	Andrén and Nilson (1979)
ye- Sefid	9	-	30	-	-	36.7	1275	1.32 [2]	-	Andrén and Nilson (1979)
-Ab (B)	10	-	30	-	-	32.8	1125	2.9 [2]	-	Andrén and Nilson (1979)
	11	-	30	-	-	34.1	1075	1.74 [2]	-	Andrén and Nilson (1979)
	12	-	30	-	-	35.6	1150	1.37 [2]	-	Andrén and Nilson (1979)
Birjand (13a)	13	23	23	23.8	27.8	19.4	1378	2.7 - 2.9 [2]	4.3 [1]	present paper

Table 4. Mating call data of triploid *Bufo pseudoraddei baturae* in comparison with *Bufo latastii* from India and Pakistan.

Taxon (ploidy)	Locality (code in Fig. 1)	WaterT (°C)	Interpulse Interval (ms)	Pulse duration (ms)	Pulse rate (s ⁻¹)	Fundamental frequency (Hz)	Call duration (s) [N of calls measured]	Intercall interval (s) [N of intervals measured]	Source
<i>B. latastii</i>	Kargil and Tangmarg, Pahalgam	no data	no data	30-60	8-13	1200-1300	2.5-6.1 [data from spectrograms]	no data	Dubois and Martens (1977)
<i>B. latastii</i> (diploid)	Skardu (49)	13	54.3	39.8	10.62	1470	4.3-6.9 [3]	4.9-6.9 [3]	present paper
<i>B. pseudoraddei baturae</i> (triploid)	Gilgit (48a) and Pasu (47, P)	7-27	27.3-86.2	19-56.7	7.38-21.28	1378-1636	1.2-4.2 [25]	2.0-6.8 [25]	Stöck et al. (1999), unpubl.

(one of) the oldest available name(s) for tetraploids in Middle and Central Asia.

New data from Pakistan

Cytometric data. Among the triploid populations reported by Stöck et al. (1999), DNA-measurements in additional specimens confirmed bisexual triploidy in altogether 82 adult specimens of *Bufo pseudoraddei baturae* from Pasu (47). Exclusively triploids were also detected by our sample survey along the upper tributaries of the Hunza (47a) and Gilgit river systems (48b, c). The record of triploids at the Shandur pass (48c, 3720 m a.s.l.) and the occurrence of triploids in the Chitral valley (48d, e) demonstrated their continuous distribution, i.e. a more or less connected range. In Chitral, sympatric occurrence of triploids with *B. stomaticus* was observed.

The flow cytometric measurements (Tab. 1, Fig. 9E) revealed all 15 specimens of *Bufo latastii* from Skardu (49) to be diploid. Although the absolute values cover a relatively large range resulting from the fixation of samples in ethanol in the field, apparently the DNA content of *B. latastii* is about 15 to 20% higher than that of diploid *B. viridis* ssp. and *B. v. kermanensis* from Iran. The karyotype of toads from Skardu comprises $2n = 22$ chromosomes; a detailed cytogenetic study will be published elsewhere. It remains to be clarified if the karyological study on a "*Bufo* spec." from Kashmir (Duda & Opendar, 1971) really represented *B. latastii* as Dubois and Martens (1977) and Roth and Ráb (1986) presumed when they considered this species diploid. In any case, long lasting speculations (see appendix: M) on the ploidy of *B. latastii* which previously were connected with signifi-

cant uncertainties in the systematics of Central Asian green toads (Borkin et al. 2000; Stöck et al., 1999) have been finished now.

Mating calls (Table 4). Mating call parameters of a single diploid male *B. latastii* from Skardu were found in the range reported for this species by Dubois and Martens (1977) from Kashmir and Ladakh. As discussed by Stöck et al. (1999), the *B. latastii* calls are rather similar to those of triploid *B. pseudoraddei baturae* from Western Karakoram and *B. p. pseudoraddei* from Western Himalayas. This can be either interpreted as convergences in isolated species or may result from the participation of *B. latastii* genes in the probably allotriploid *B. p. baturae*, but up to now, exact explanations are not available.

Morphology and taxonomy. The morphology of triploids from Shandur Pass (48c) and Chitral (48d, e) was similar to that of *B. pseudoraddei baturae* from Gilgit (Stöck et al., 1999); therefore, we consider them to represent the same taxon.

The 15 toads examined from Skardu (49) were clearly identified as *Bufo latastii* Boulenger, 1882 (= *B. siachinensis* Khan, 1997). The external morphology and the coloration are very similar to the lectotype of *B. latastii* (Fig. 9A-D). Furthermore, the characteristic ventral dark pattern comprising blackish, up to eye-sized, sometimes connected spots and an abrupt darkening of the caudal third of the belly including the base of the hind legs was found to occur in the *B. latastii* lectotype, the *B. siachinensis* holotype, and always in the toads from Skardu also (Fig. 9C, D).

Table 5. Evaluation (overview) of methods previously used by different authors for the determination of diploid and polyploid green toads. For detailed information see text.

Method of determination	Unequivocalness	Applicability in the field	Abbr. in the appendix
Karyotype, karyogram, counting of chromosomes	yes	no	chrom. count.
Flow cytometry	yes, if applied professionally	no, but blood samples can shortly be stored in ethanol	flow cytom.
Microdensitometry (Feulgen staining), cytometry	yes, if applied professionally	yes, if blood smears are stored in 5% formaldehyde solution	microdens., cytom.
Electrophoresis	no, only prognosis possible	no	electrophor.
Measurement of erythrocytes	no, only prognosis possible	collection of air dried blood samples easily possible	erythr. size
Mating call analysis	probably yes, for distinguishing between diploid and polyploid (triploid, tetraploid) forms, but see <i>B. latastii</i>	yes	calls
External morphology, morphometry	no, only prognosis possible	yes	ext. morph.
Form and size of the clutch	no, often misleading	-	clutch

Evaluation of methods for the identification and determination of the ploidy in Asian green toads (Table 5)

Some forms/species of Middle and Central Asian green toads have been partly identified using misleading or ambiguous methods (comp. also Stöck and Grosse, 1997a).

The karyological analysis still remains an essential tool. The treatment with colchicine and the preparation of bone marrow, spleen or intestine tissue for the counting of stained chromosomes (e.g., Schmid, 1978; Macgregor and Varley, 1983) requires the killing of the animals. The obtaining of blood by heart puncture with micro-syringes (e.g., Schroer, 1996) and the determination of the ploidy by chromosome counts from blood cultures (Castellano and Giacoma, 1998) causes little mortality but requires the transport of the toads to the laboratory.

Flow cytometry is another unequivocal technique (Murphy et al., 1997 for review). The preferable storage of blood by freezing in liquid nitrogen is usually limited in the field. Ethanol fixation of blood obtained from anaesthized toads allows a storage for some weeks and the ploidy determination by flow cytometry if refrigeration is possible (e.g., Stöck et al., 1999), but does not allow the exact determination of absolute DNA-contents.

Feulgen staining of erythrocytes and the microdensitometrical determination of their DNA-

content provides also unequivocal results (Stöck and Grosse, 1997a). Although better results can be obtained if applied in the laboratory since the storage of air dried blood causes a loss of stainability, we recently got good results with blood smears which were stored in 5% formaldehyde solution until staining (our unpublished data). The obtaining of blood smears from the tip of the finger seems to be of very little damage for the animals, but requires to prevent the pollution of blood samples with skin mucus.

Significant differences in the average erythrocyte size allow a prognosis of the ploidy level (Stöck and Grosse 1997a). Discrimination problems occur because some populations exhibit values in the overlapping range between diploid and tetraploid toads. In addition, the classification of triploid individuals remains unsolved. In probably all-triploid populations from Karakoram, the mean erythrocyte areas exhibited significant differences to diploid and tetraploid populations (Stöck et al., 1999), but the variability of the individual erythrocyte size shows a large overlapping with diploid and tetraploid specimens. Unfortunately, these phenomena also prevent an exact analysis of the ploidy level of museum and type specimens with the technique of Mercadal (1981).

Results of protein electrophoresis (e.g., Borkin and Sokolova 1989, Mezhzherin and Pisanets, 1995a, 1995b) can usually not substitute the preceding ploidy determination since "electromorphs" may cause misinterpretations. Some authors of electrophoretic stud-

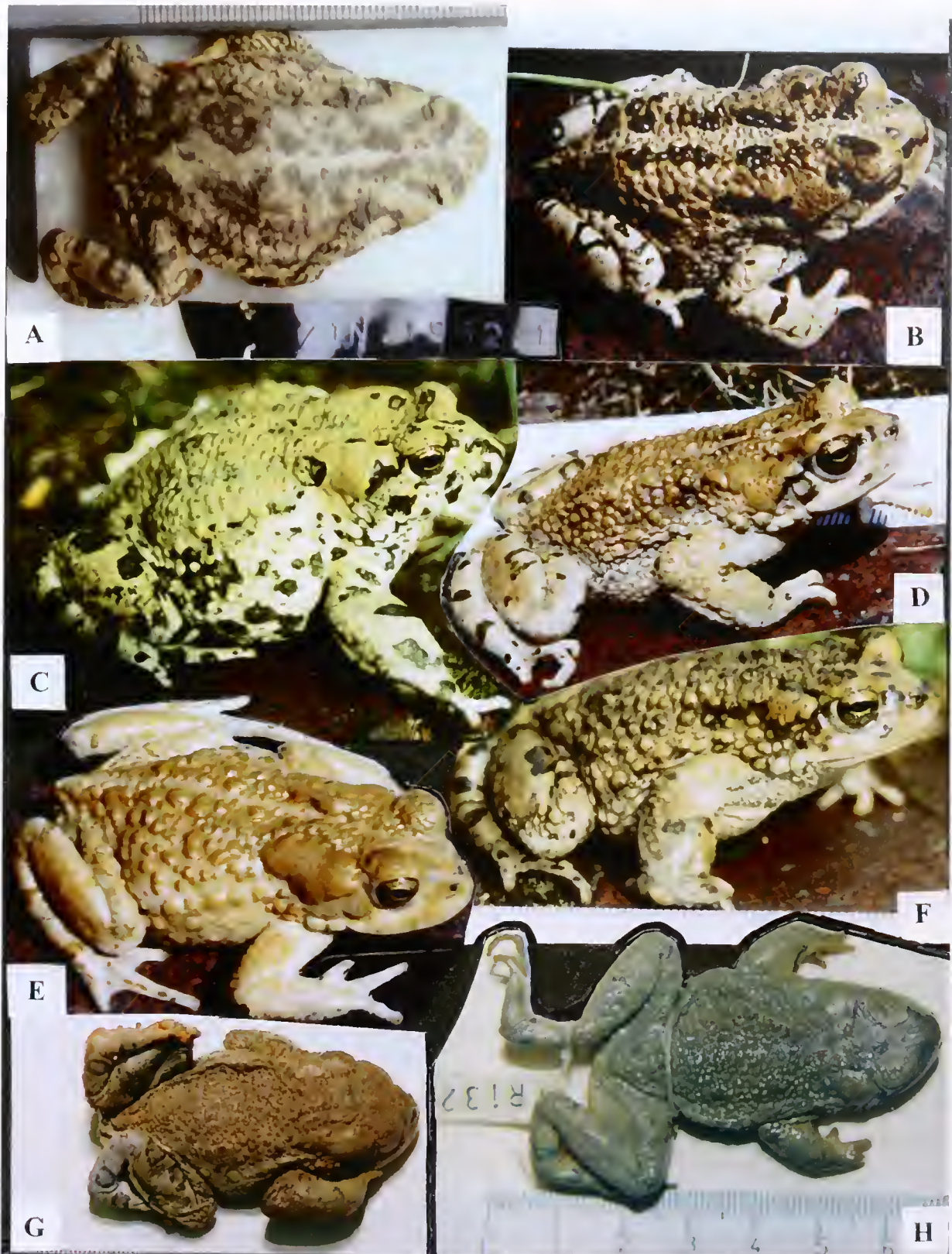


Figure 8. A - Lectotype (present designation) of *Bufo oblongus* Nikolsky, 1896 (Z ISP 1952.1) from Birjand, E-Iran. B - Topotypic tetraploid female *Bufo oblongus* from Birjand. C - Diploid male from Gholaman. D - Topotypic tetraploid male *Bufo oblongus* from Birjand. E - Topotypic diploid male of *Bufo viridis kermanensis* Eiselt & Schmidtler, 1971. F - Tetraploid male from Baghestan. G - Holotype of *Bufo kavirensis*, Andr  n & Nilson, 1979. H - Holotype of *Bufo luristanicus* Schmidt, 1952.

ies did not describe whether or how they determined the ploidy level (e.g., Mezhzherin and Pisanets, 1991).

At any given temperature mating calls of tetraploid toads exhibited longer pulses and interpulse intervals resulting in lower pulse rates than diploid toads (Stöck 1997a, 1998a), a finding which exhibits parallels in other diploid/tetraploid anuran species (Hylidae, Leptodactylidae) and artificial tetraploids suggesting that differences are caused by polyploidy (Gerhardt, 1994: 317).

For triploid toads from northern Kyrgyzstan (Castellano et al., 1998) and triploid populations from northern Pakistan (Stöck et al., 1998, 1999) call parameters were found to resemble those of tetraploid toads. Therefore, the mating call analysis seems suitable for distinguishing between diploid and polyploid (triploid, tetraploid) green toads. However, independently from polyploidisation, speciation in the *B. viridis* complex appears to take place also within each ploidy level and as in other anurans, evolutionary divergences in sympatry as well as convergences of call parameters in allopatry can be expected. The latter seems to be the case in diploid *B. latastii*, from which pulse rate data (Dubois and Martens, 1977) suggested a polyploid species (Stöck, 1998a).

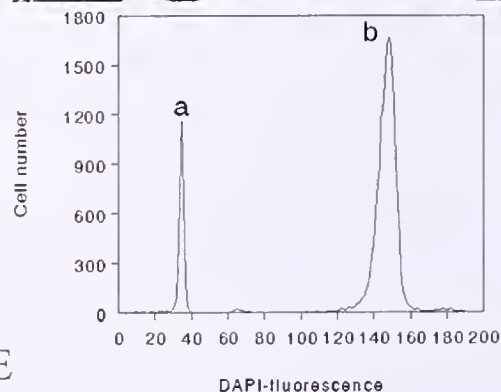
Many morphometric traits exhibited differences of the means but values showed large intersections between both diploid and tetraploid toads and morphometric parameters were not suitable for ploidy determination (Stöck, 1997b). The study announced by Roth (1986) on "about 2000 specimens from the whole range" has never been published (Roth, pers. comm.). In advance, Roth (1986) considered morphological characters "useless" for taxonomy but without determination of the ploidy level of the collection material. Multivariate analyses confirmed relationships between the ploidy level and the external character syndrome in diploid and tetraploid green toads (Stöck, 1997b; Castellano et al., 1998). Triploid toads from Kyrgyzstan exhibited more distinct differences to diploid than to tetraploid specimens (Castellano et al., 1998). Triploid populations in the Karakoram showed significant differences to both diploid and tet-

raploid toads from Central Asia in many characters with univariate methods (Stöck et al., 1999). A prognosis for the purely morphometric classification of diploid, triploid and tetraploid toads is possible with multivariate methods and this appears to be *one* tool for the prognostic assortment of preserved specimens in collections. The prognosis can be improved if morphometric data are combined with erythrocyte size data (Stöck, 1997b; Stöck and Grosse, 1997a; Stöck et al., 1999). In any case, the use of exact methods for ploidy determination is highly recommended (e.g., Borkin et al., 2000).

Pisanets (1987) indicated differences in form and size of the clutch between diploid and tetraploid toads



Figure 9. A, B - Lectotype of *Bufo latastii* Boulenger, 1882 (BMNH 1947.2.21.28, formerly 72.4.17.223), scale for B: 1 centimetre. C, D- Male *B. latastii* (ZMB 62721) examined from Skardu, Baltistan. E - Histogram obtained by DNA flow cytometry from a mixture of DAPI stained blood samples with chicken as the standard (a), CV = 2.94%, and diploid *B. latastii* from Skardu (b), CV = 2.74%. Total cell number 22 744.



from Turkmenistan (Kurukhaudan village, 12). The character is occasionally misleading (Kuzmin, 1995: 94; Stöck and Grosse, 1997a) although it was infrequently used for the identification of toads for further investigations (e.g., Mezhzherin and Pisanets, 1990).

Distribution

In general, the present map (Fig. 1) does not completely reflect the occurrence of green toads whose ploidy is known but also illustrates the recent degree of investigation.

Diploid toads (black arrows without starlet). The records of green toads found to be diploid in Middle Asia are distributed in the Turan Basin and are also concentrated at the foothills of the high mountains. Diploids have been found along the bottom part of the Kopet Dag mountains (7, 8, 10, 11); a second group of records is to be seen in the Kafirnigan and Vakhsh river valleys (23, 25, 28, 29). The last records seem to exemplify a dispersion of diploid toads along the rivers into the mountain valleys. The western and particularly the northern Tien Shan form a third region with several records of diploid toads (31a, 36, 38, 39, 59, 59a). More distant from the mountains researches combined with ploidy determination have only sporadically been carried out. Merely some localities with doubtless diploid toads near the lower Amu-Darya (9, 14) and Zervashan river (17, 18) are known. The record of diploid toads from the Chingzhal river (61) in Kazakhstan by Golubev (1990) appears to be doubtful (Dujsebayaeva et al., 1997). The main range (maps in Dubois and Martens, 1977, Stöck et al., 1999) of the diploid *B. latastii* (N, 49) is the rather humid Kashmir valley and the surrounding rather arid mountain ranges.

The small and highly generalized map by Kuzmin (1995: 182) and the more detailed one (Kuzmin, 1999: 479) show either a continuous range or many separate symbols of (diploid) *B. viridis* in Middle Asia and Kazakhstan. Both maps cannot reflect the detailed records and/or were not based on karyological studies. Therefore, Kuzmin (1995, 1999) also announced that the distribution requires additional investigations. However, Kuzmin's maps refer to the occurrence of diploid green toads in the Turan Basin along the rivers whereas the symbols for (diploid) *B. viridis* in the Inner Tien Shan and around the Issyk-Kul appear to be very doubtful (e.g. see Borkin, 1989).

In spite of only few references which contained data on the ploidy level and on the altitudinal distribution, the occurrence of diploid toads in Middle Asia apparently exceeds 1600 m a.s.l. only in rare cases (appendix; Castellano et al., 1998: "At least in Kazakhstan and Kyrgyzstan no diploid populations have

been found above 2000 m a.s.l."). Many papers (summarized e.g. by Meinig, 1995) reporting the occurrence of "*B. viridis*" until 4000 m a.s.l. in Central Asia, very probably represent data on polyploid toads. This also may account for Kuzmin's (1999) material who reported on *B. viridis* up to 3200 m a.s.l. in Middle Asia.

Tetraploid toads (white arrows). The tetraploid toads are largely distributed in the Middle and Central Asian mountain systems. They have been described from the Kopet Dag (5, 6, 8, 11, 12), the Gissar range including its southern spurs (21 to 27, 27a, 30), the western Tien Shan (31a, 32, 33, 40), the northern Tien Shan and the Issyk-Kul gorge (39, 51 to 59, 59b, 60), the Central Tien Shan (42, 51), the margins of the Taklamakan desert (43, 50?), the region between Zailiyskiy Alatau and lake Balkhash (60, 37, 37a, 37b), the Dzungarian Alatau (60a, 60b), the eastern Tien Shan (63), and Dzungaria (62, 64, 66 to 72). In the Pamirs, tetraploid toads have been found in the western (34, 35) and in the central parts (45). Furthermore, Stöck (1998b) found toads from eastern Pamirs (44) to be tetraploid. They were recently described by Fei et al. (1999) as a new subspecies (T). The present map provides arguments for a rather continuous distribution of tetraploid toads from Eastern Tien Shan to the Dzungarian Gobi in Mongolia. Interestingly, eastern of about 80° E only records of tetraploids and obviously no record of diploid toads have been made. Various records underline the high ecological plasticity especially of the tetraploid green toads (e.g. Dujsebayaeva et al., 1997). The dry centers of the large continental deserts Kyzylkum, Karakum, Muyunkum and Betpak-Dala seem to be not suitable as habitats of (tetraploid) green toads but this might be also caused by the recent low degree of investigation. Considering some records of tetraploids in the eastern plane regions, some additional records of tetraploid toads in the Turan lowlands can be expected in future. The tetraploids in the West of the known range (Kopet Dag) may have a rather continuous distribution via the mountains of Afghanistan until those of the Pamiro-Alai-System, but data from Afghanistan are recently too scarce for a detailed analysis.

Triploid toads (black arrows with starlet). For the first time, probable triploidy of three specimens was detected by Bachmann et al. (1978: "36% more DNA than diploid *Bufo viridis*") in toads (presumably) originating from Kabul (48f in Fig.1; Hemmer et al., 1978: 352, 370). Triploid individuals have been detected in south-western Turkmenistan (5), in northern Kyrgyzstan (39) and south-eastern Kazakhstan; the last record was reported without particular locality

(Borkin et al., 1997, 2000) and we did not draw it in the map. The rare occurrence of triploid individuals in the Central Pamirs (45) has been concluded from isozyme data (Mezhzherin and Pisanets 1990). Most of the authors supposed a hybrid origin of triploids as a result of mismatings between diploid and tetraploid toads or only noted the occurrence in contact zones of diploid and tetraploid toads (Borkin et al., 1997, 2000). Preliminarily, Lattes (1997) and Cervella et al. (1997) indicated that triploids from Kyrgyzstan (Kokjar, near 39; Castellano et al., 1998) do not originate from hybridizations between diploid and tetraploids but seem to be closely related forms of the tetraploids. Presumably all-triploid populations of green toads from the Karakoram range and Western Himalayas (46, 47, 48a) have been discovered by Stöck et al. (1998) and were described as a new subspecies (Stöck et al., 1999). The new data from Pakistan (47a, 48b-e) suggest that triploids, which form at least at some localities (e.g., 47) all-triploid gonochoristic populations, are distributed along the upper tributaries of the Gilgit river (48b), they live at the Shandur pass (48c, 3720 m a.s.l), and also in the Central Hindukush, i.e. the Chitral valley (48d, e). Interestingly, in the Karakoram exists obviously an eastern limit of the distribution of triploids situated between their most eastern record (48a) and the most western one (49) of diploid *B. latastii* in the gorge of the Indus river. Based only on morphological characters, Baig (1998) reported on the sympatric occurrence of "*Bufo latastii*" and "*B. pseudoraddei*" in the "Neelam valley" (= Jhelum valley) of Azad Kashmir in eastern Pakistan.

Generally, the correlation of distributional data on green toads with global climatic factors appears to be problematic because the local or microclimatic conditions to which the animals are adapted may differ strongly from the climatic zone in which any locality is situated.

Zoogeographic implications. Borkin (1999: 350) considered "the *B. viridis* group as an indicator of southern limits of the Palearctic in arid regions". Mazik et al. (1976) as well as Pisanets (1978) already reported an allopatric occurrence of diploid and tetraploid green toads because they have different ecological preferences. This hypothesis is principally supported by the present map but it seems more appropriate to call the ranges parapatric (Borkin et al., 1997). Many authors (Pisanets and Shcherbak, 1979; Toktosunov, 1984; Borkin et al., 1986b, c; Borkin and Kuzmin, 1988) arranged the tetraploids of the arid foothill regions in contrast to those of the high mountains. In our opinion, it appears possible that the limiting climatic factors in the high mountains as well as in

the more continental high plains are similar and are obviously suitable only for polyploid green toads.

At the moment, the causes for the specific distribution pattern remain speculation. Kuzmin (1995: 189, 1999) refers to the high degree of temperature tolerance of tetraploid green toads (-30°C to 45°C). In the high mountain habitats as well as in the continental deserts strong daily and annual variations of temperatures as well as a high mean annual solar radiance (e.g. in the northern Asian deserts 2700-2800 h, in the interior Tien Shan > 2600 h, see Zlotin, 1997) might have caused a genetically caused selective advantage of the polyploid forms. This may also account for the missing of diploid toads in the east of the range where only tetraploids have been detected. The eastern boundary of the range of tetraploid green toads and the obviously parapatric occurrence of *B. raddei* in Northern China and Western Mongolia was discussed by Peters (1971: "*B. viridis*" for tetraploids), Borkin and Kuzmin (1988), and Stöck (1998b). The most western known records of tetraploids (Kopet Dag, Khorasan) seem to correspond with the region of transition from winter-mild, summer-dry steppe climates of Middle Asia and Afghanistan to the winter-humid, summer-dry climates of Mediterranean type in Iran (Walter and Lieth, 1967; Müller, 1996). The deserts of Central Iran with fewer than 100 mm rainfall/year and large sand or salt areas seem to separate the polyploids in the East of Central Iran (and Afghanistan?) from the diploids in the West. Although *B. surdus* may provide unexpected karyological data, at the moment, in spite of only few studies, records of polyploid green toads in the West of Iran appear to some extent improbable. This may rather result from the history of distribution than from the possible relationship between polyploidy and environmental selective pressure.

The present image of the distribution of diploid and tetraploid toads possibly also corresponds to the experience that (especially allo-)polyploid organisms may have advantages in regions with extreme or changing environments (Futuyama 1990: 69 - "polyploids are more resistant"), when colonizing new habitats (Bretagnolle et al. 1998) or were considered to have a higher competitive ability (e.g., Lumaret et al., 1997). However, particularly the distribution of diploid plant species and their polyploid relatives probably more strongly reflects the influence of historical factors than of their current ecological requirements (Bretagnolle et al. 1998) or adaptedness. Morescalchi (1990) stated: "In amphibians, changes in genome size (...), far from being random, they are related to metabolic and ontogenetic factors which are of crucial importance in the adaptive strategies of these animals".

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Appendix 1.

Loc.-No.	Ploidy	Topographic description	Source	Method
1	2n	Iran, Zagros Mountains, Gholaman, 30 km W Khorram Abad, 33°25' N, 48°12' E	present paper	erythr. size, microdens.
1a	2n	Iran, SW-slope of Zagros mountains, Khuzestan Province, Choqa Zanbil, 32°31' N, 48°32' E, 560 m a.s.l.	present paper	flow cytom.
2	2n	Iran, N-slope of Elburz mountains, valley 15 km S Gorgan, approx. 1100 m a.s.l.	Stöck (1995)	chrom. count. of larvae and juveniles
2a	2n	Iran, S-slope of Elburz mountains, N of Theran, near Polur, approx. 2350 m a.s.l.	Martens unpublished, present paper	calls
2b	2n	Iran, S-slope of Elburz mountains, N of Theran, valley NE of Fasham, approx. 2540 m a.s.l.	Martens unpublished, present paper	calls
	2n	Iran, S-slope of Elburz mountains, Lar valley NE	Andrén and Nilson (1979), present paper	calls
2c	2n	Iran, Tehran Province, N environs of Tehran, garden of Plant Pests and Diseases Research Institute	Borkin et al. (2000)	flow cytom.
2d	2n	Iran, Tehran Province, approx. 70 km W of Karaj, Karpuz-Abad village	Borkin et al. (2000)	flow cytom.
3	2n	Iran, NE, frontier zone near Turkmenistan, approx. 50 km NE Gonbad-e-Kavus, 250 m a.s.l., 37°38' N, 55°29' E	Stöck (1997a), Stöck and Grosse (1997a), Stöck (1998a)	chrom. count. of larvae, adults, erythr. size
4	4n	Turkmenistan, Nebit-Dagshui Rayon, N-slope of Bolshoi Balkhan, approx. 15 km S of Oglanly village, 500 m a.s.l., 39°43' N, 54°29' E	Stöck (1997a), Stöck and Grosse (1997a), Stöck (1998a)	chrom. count. of larvae, adults, erythr. size, calls
5	2n	Turkmenistan, Ashgabadskaya oblast, near Danata	Pisanets (1978), Borkin et al. (1986a)	chrom. count.
	2n	- " -	Mezhzherin and Pisanets (1990), Pisanets (1992a)	ext. morph.
	4n, 3n	- " -	Pisanets (1978)	chrom. count.
	4n	- " -	Borkin et al. (1986a)	chrom. count.
	4n	- " -	Mezhzherin and Pisanets (1990), Mezhzherin and Pisanets (1991), Mezhzherin and Pisanets (1995a, b)	chrom. count. and/or ext. morph.
	4n	- " -	Ataev (1987), Pisanets (1992a)	ext. morph.
	4n	- " -	Pisanets (1992b)	chrom. count., ext. morph.
	4n	Turkmenistan, Ashgabadskaya oblast, stream 2-4 km SE of Danata village and warm spring approx. 4 km SE of Danata, 200 m a.s.l.	Stöck (1997a), Stöck and Grosse (1997a), Stöck (1998a)	chrom. count. of larvae, adults, erythr. size, calls
?	4n	"South-west Kopet-Dagh", not exactly localized	Pisanets and Vasilenko (1995)	method not described
6	4n	Turkmenistan, Kuruchsudon-Reserve, Kopet-Dag (not exactly localized)	Borkin et al. (1986a)	chrom. count. and/or flow cytom.
7	2n	Turkmenistan, Kyzyl-Arvatshui Rayon, Kopet-Dag-Range, valley approx. 25 km SW of the station Bami S of the pass, 750 m a.s.l., 38°37' N, 56°38' E	Stöck (1997a), Stöck and Grosse (1997a), Stöck (1998a)	chrom. count. of larvae, erythr. size, microdens.
8	2n	Turkmenistan, Aydere-oasis, E Kara-Kala	Borkin et al. (1986a)	chrom. count. and/or flow cytom.
	4n	Turkmenistan, Adere-oasis, E Kara-Kala	Borkin et al. (1986a)	chrom. count. and/or flow cytom.
	4n	Turkmenistan, Kara-Kala	Mezhzherin and Pisanets (1995a, b)	chrom. count. and/or ext. morph.
9	2n	Turkmenistan, lake Sarykamys	Borkin et al. (1986a)	chrom. count.
9a	2n	Kazakhstan, Guryev Town, Chornaya Rechka	Schneider and Egiasaryan (1995), Dujsebajeva et al. (1997)	calls
10	2n	Turkmenistan, Ashgabadskaya oblast, Bacharden	Pisanets (1992a)	ext. morph.
	2n	- " -	Mezhzherin and Pisanets (1991)	method not mentioned
	2n	Turkmenistan, Ashgabadskaya oblast, Bacharden	Mezhzherin and Pisanets (1995a, b)	chrom. count. and/or ext. morph.
	2n	Turkmenistan, Ashgabadskaya oblast, S Bacharden, approx. 10 km W Kelyata, 500 m a.s.l., 38°14' N, 57°31' E	Stöck (1997a), Stöck and Grosse (1997a), Stöck (1998a)	chrom. count. of larvae, erythr. size, microdens.
11	2n	Turkmenistan, Ashgabadskaya oblast, near Ashgabad	Borkin et al. (1986a)	chrom. count.
	2n	- " -	Mezhzherin and Pisanets (1990), Mezhzherin and Pisanets (1991)	ext. morph.
	2n	Turkmenistan, Ashgabad, village Kodzh	Mezhzherin and Pisanets (1991)	method not mentioned
	2n	- " -	Mezhzherin and Pisanets (1995a, b)	chrom. count. and/or ext. morph.
	2n	Turkmenistan, Ashgabadskaya oblast, near Ashgabad	Pisanets and Vasilenko (1995)	method not described
	2n	- " -	Pisanets (1991)	chrom. count.
	2n	Turkmenistan, Ashgabadskaya oblast, Ashgabad	Stöck (1995)	chrom. count. of larvae
	4n	Turkmenistan, Ashgabad	Roth and Ráb (1986)	chrom. count.
12	4n	Turkmenistan, village Kuruchaudan	Pisanets (1987)	clutch
12a	2n	Iran, 20 km WNW Kapkan, Khorasan, 37°22' N, 58°32' E, 1670 m a.s.l.	present paper	erythr. size, microdens.
13	4n	Iran, 10 km NE Baghestan, Khorasan, N of Kuh-e-Kalat, 34°09' N, 58°25' E, 1900 m a.s.l.	Stöck et al. (1998a), present paper	chrom. count., erythr. size, microdens. and flow cytom.
13a	4n	Iran, Khorasan, Birjand, 32°33' N, 59°10' N, about 1500 m a.s.l.	present paper	chrom. count., flow cytom.
13b	2n	Iran, Kerman Province, Kerman, 30°18' N, 57°05' E, 1860 m a.s.l.	present paper	chrom. count., flow cytom.
13c	2n	Iran, Kerman Province, Bahr-e-Aseman Mountains, Sarduiyeh village in Sarduiyeh District, 2500 m a.s.l.	Borkin et al. (2000)	flow cytom.
14	2n	Turkmenistan, lake Shach-Senem (not exactly localized, SE of 9)	Borkin et al. (1986a)	chrom. count. and/or flow cytom.
15	2n	Turkmenistan, Ashgabadskaya oblast, near Iolotan	Mezhzherin and Pisanets (1990), Mezhzherin and Pisanets (1991)	ext. morph.
16	4n	Badkhyz-Reserve, Akar Chechme	Pisanets (1978)	chrom. count.
	4n	- " -	Borkin et al. (1986a)	chrom. count.
	4n	- " -	Mezhzherin and Pisanets (1995a, b)	chrom. count. and/or ext. morph.
17	2n	Uzbekistan, Buchara	Roth and Ráb (1986)	chrom. count.

18	2n	Uzbekistan, Samarkand	Borkin et al. (1986a)	chrom. count
19	4n	Uzbekistan, Dzhisakskaya oblast, Rayon Farish, Nuratau-Reserve, N-slope of Nuratau Range, 900 - 1600 m a.s.l., 40°35' N, 66°30' E	Stöck (1997a), Stöck and Grosse (1997a), Stöck (1998a)	chrom. count. of larvae, adults, erythr. size, calls
	4n	Uzbekistan, Dzhisakskaya oblast, Rayon Farish, S bank of Aidar-Kul near of Nuratau-Range, 300 m a.s.l.	Stöck (1997a), Stöck and Grosse (1997a), Stöck (1998a)	chrom. count. of larvae, erythr. size, microdens., calls
20	4n	Tadzhikistan, 60 km E of mouth of Janob into Zeravshan river, right bank of Zeravshan river, near Pastigav	Kryukov et al. (1985)	chrom. count.
21	4n	Tadzhikistan, Gissar-Range, Ziddi, 3000 m a.s.l.	Borkin et al. (1986a)	chrom. count.
22	4n	Tadzhikistan, Ramit-gorge, Chuligaram	Borkin et al. (1986a)	chrom. count.
	4n	Tadzhikistan, Ramit-gorge, Chuligaram	Mezhzherin and Pisanets (1995a, b)	chrom. count. and/or ext. morph.
	4n	- " -	Pisanets (1992b)	chrom. count., ext. morph.
	4n	Tadzhikistan, 15 km SW of the mouth of Sardan-Miena and Sorbo, gorge of Kafirnigan, near Jayroz	Kryukov et al. (1985)	chrom. count.
23	2n and 4n	Tadzhikistan, Dushanbe	Roth and Ráb (1986)	chrom. count.
	4n	Tadzhikistan, N Dushanbe	Kryukov et al. (1985)	chrom. count.
24	4n	Uzbekistan, Gissar-Range, 20 km of mouth of Tupalang-Darya, 800 m a.s.l.	Borkin et al. (1986a)	chrom. count.
25	2n	Tadzhikistan, 90 km SW Dushanbe, Kafirnigan-valley	Borkin et al. (1986a)	chrom. count.
26	4n	Tadzhikistan, 90 km S Dushanbe, Kafirnigan-valley, near Isambai	Pisanets (1992b)	chrom. count., ext. morph.
27	4n	Tadzhikistan, S Pamir, near Lyangar	Mezhzherin and Pisanets (1990)	ext. morph.
	4n	Tadzhikistan, S Pamir, near Lyangar	Mezhzherin and Pisanets (1991)	method not mentioned
	4n	- " - 1800 m a.s.l.	Pisanets (1992b)	chrom. count., ext. morph.
27a	4n	Tadzhikistan, near Faizabad	Mezhzherin and Pisanets (1991)	method not mentioned
	4n	Tadzhikistan, near Faizabad	Pisanets (1991)	chrom. count.
	4n	Tadzhikistan, near Faizabad	Mezhzherin and Pisanets (1995a, b)	chrom. count. and/or ext. morph.
	4n	- " - localization using the information... 120 km N of Dushanbe" in:	Pisanets (1992a)	ext. morph.
	4n	- " -	Pisanets (1992b)	chrom. count., ext. morph.
	4n	Tadzhikistan, Vakh valley, environs of Obi-Garm	Mezhzherin and Pisanets (1991)	method not mentioned
	4n	Tadzhikistan, Obi-Garm, 2300 m a.s.l.	Pisanets (1992a)	ext. morph.
	4n	Tadzhikistan, Obi-Garm	Mezhzherin and Pisanets (1995a, b)	chrom. count. and/or ext. morph.
	4n	- " -	Pisanets (1992b)	chrom. count., ext. morph.
27b	4n	Tadzhikistan, mouth of Komarou-river, 2000 m a.s.l. (not exactly localized)	Borkin et al. (1986a)	chrom. count.
28	2n	Tadzhikistan, 10-12 km SW of the mouth of Vakhsh and Javansu, near Kurgan-Tjube	Kryukov et al. (1985)	chrom. count.
	2n	Tadzhikistan, 10-12 km W of the mouth of Vakhsh and Javansu, left of Vachsh, Kuibyshevskii Rayon	Kryukov et al. (1985)	chrom. count.
	2n	Tadzhikistan, 50 km NE of mouth of Vakhsh into Pyandzh, near Dusti	Kryukov et al. (1985)	chrom. count.
29	2n	Tadzhikistan, Chirik	Borkin et al. (1986a)	chrom. count.
	2n	environs of Chaartuz, Chirik	Pisanets (1991)	chrom. count.
	2n	Tadzhikistan, Beshkentkie peski, valley of Kafirnigan river, environs of Chaartuz	Mezhzherin and Pisanets (1991)	method not mentioned
	2n	- " -	Pisanets (1992a)	ext. morph.
30	4n	Tadzhikistan, S of Aktau-Range, 80 km S Dushanbe	Kryukov et al. (1985)	chrom. count.
31	4n	Uzbekistan, Tashkent	Borkin et al. (1986a)	chrom. count. and/or flow cytom.
	4n	- " -	Kudryavcev et al. (1988)	cytometry
	4n	- " -	Roth and Ráb (1986)	chrom. count.
	4n	Uzbekistan, Tashkent, 450 m a.s.l., 41°16' N, 69°13' E	Stöck (1997a), Stöck and Grosse (1997a), Stöck (1998a)	chrom. count. of larvae, adults, erythr. size, calls
31a	2n	Kazakhstan, environs of Chimkent	Mezhzherin and Pisanets (1995a, b)	chrom. count. and/or ext. morph.
	4n	Kazakhstan, environs of Chimkent	Mezhzherin and Pisanets (1991)	method not mentioned
31b	4n	Kazakhstan, Kyzyl-kum desert, 50 km SW of Bairkum village, Chimkent region, 250 m a.s.l., 67°25' N, 42°02' E	Dujsebayaeva et al. (1997), Castellano et al. (1998)	chrom. count.
31c	4n	Kazakhstan, Chimkent region, Jagbagly village, 1100 m a.s.l., 70°32' N, 42°25' E	Dujsebayaeva et al. (1997), Castellano et al. (1998)	chrom. count.
32	4n	Uzbekistan, 80 km E Tashkent, entry of Chatkal-Reserve, 5 km SE Burchmulla, 900 m a.s.l., 41°35' N, 70°07' E	Stöck (1997a), Stöck and Grosse (1997a), Stöck (1998a)	chrom. count. and/or erythr. size, calls
33	4n	Uzbekistan, Kuraminsky-Range, 3000 m a.s.l.	Borkin et al. (1986a)	chrom. count.
34	4n	Tadzhikistan, S Pamir, near Khorog	Mezhzherin and Pisanets (1990)	ext. morph.
	4n	Tadzhikistan, Gorno-Badakhshan, S Pamir, near Khorog	Mezhzherin and Pisanets (1991)	method not mentioned
	4n	- " -	Mezhzherin and Pisanets (1995a, b)	chrom. count. and/or ext. morph.
	4n	- " -	Pisanets (1992a)	ext. morph.
35	4n	Tadzhikistan, S Pamir, near Ishkashim	Mezhzherin and Pisanets (1990)	ext. morph.
	4n	Tadzhikistan, Gorno-Badakhshan, S Pamir, near Ishkashim	Mezhzherin and Pisanets (1991)	method not mentioned
	4n	- " - 1800 m a.s.l.	Pisanets (1992b)	chrom. count., ext. morph.
	4n	Tadzhikistan, S Pamir, near Ishkashim	Mezhzherin and Pisanets (1995a, b)	chrom. count. and/or ext. morph.
36	2n	Kazakhstan, Dzhambul	Roth and Ráb (1986)	chrom. count.
36a	2n	(outside the map) Kazakhstan, Tengis Lake, 12 km W of Abaya village, about 50°40' N, 69°40' E	Dieterich leg., examined by Stöck, unpublished	flow cytometry (one specimen)
37	4n	Kazakhstan, desert near Burubaital, S Balchash lake region	Egembergdieva (1983) cited by Borkin et al. (1986a)	unknown, original paper not available
	4n	Kazakhstan, desert near Burubaital, S Balchash lake region	Borkin et al. (1995)	flow cytometry

37a	4n	Kazakhstan, Karaoi village, 350 m a.s.l., 74°47' N, 45°54' E	Dujsebayaeva et al. (1997), Castellano et al. (1998)	chrom. count., calls
37b	4n	Kazakhstan, Zhidely Channel, Ili River Delta, 370 m a.s.l., 75°12' N, 45°18' E	Dujsebayaeva et al. (1997), Castellano et al. (1998)	chrom. count., calls
38	2n	Kyrgyzstan, Chu-valley, 650 m a.s.l.	Mazik, Kadyrova and Toktosunov (1976) and cited by Borkin et al. (1986a)	chrom. count.
	2n	Kyrgyzstan, Chu-valley	Toktosunov and Mazik (1977)	method not mentioned
	2n	Kyrgyzstan, Tulek	Castellano et al. (1998)	chrom. count., calls
	2n	Kyrgyzstan, Tyulyok, not exactly localized	Borkin et al. (1986a)	chrom. count. and/or flow cytom.
39	2n	Kyrgyzstan, Frunze (Bishkek)	Bachmann et al. (1978)	cytophotometry
	2n	- " -	Borkin et al. (1986a)	chrom. count. and/or flow cytom.
	3n	Kyrgyzstan, S Bishkek	Kuzmin (1995: 187)	method not described
	4n	Kyrgyzstan, Frunze (Bishkek)	Borkin et al. (1986a)	chrom. count.
	4n	Kyrgyzstan, environs of Frunze (Bishkek)	Mezhzherin and Pisanets (1991)	method not mentioned
	4n	- " -	Bachmann et al. (1978)	cytophotometry
	2n	Kyrgyzstan, Bishkek (Frunze)	Stöck (1997a), Stöck and Grosse (1997a)	chrom. count. and/or erythr. size
?	4n	Kyrgyzstan, Kyrgyzskii Khrebet, 1200 m a.s.l. and 2500 m a.s.l., not exactly localized	Fikhtman (1989)	method not mentioned
?	2n, 3n, 4n	Kyrgyzstan, Kok-jar, 25 km S of Bishkek, approx. 1300 m a.s.l., artificial basin about 6 km from the village	Castellano et al. (1998)	chrom. count., calls
40	4n	Kyrgyzstan, Toktogul-valley, 900 m a.s.l.	Toktosunov (1984) and cited by Borkin et al. (1986a)	chrom. count.
41	2n?	Kyrgyzstan, SW slope of Fergana-Range, near Arslanbob, 1800 m a.s.l.	Pisanets and Shcherbak (1979)	method not described
	3n	- " -	Stöck (unpublished)	chrom. count. (one juvenile animal)
	4n	- " -	Borkin et al. (2000)	method not mentioned
42	4n	Kyrgyzstan, Arpa-valley, 3500 m a.s.l.	Toktosunov (1984) and cited by Borkin et al. (1986a)	chrom. count.
43	4n	China, Kashgar, 39°29'N, 76°02'E, 1350 m a.s.l.	Stöck (1998b)	chrom. count., flow cytom., and/or erythr. size, calls
44	4n	China, E-Pamir, Taxkurgan, 37°47'N, 75°14'E, 3350 m a.s.l.	Stöck et al. (1998a), Stöck (1998b)	chrom. count., calls
45	4n	Tadzhikistan, Central Pamir, lake Jashikul, 3734 m a.s.l.	Toimastov (1989)	ext. morph.
	4n	- " - (also 3n, 2n ?)	Mezhzherin and Pisanets (1990)	ext. morph.
	4n	- " -	Mezhzherin and Pisanets (1991)	method not mentioned
	4n	- " - (also 3n, 2n ?)	Pisanets (1992a)	ext. morph.
	4n	- " - (also 3n, 2n ?)	Pisanets (1992b)	chrom. count., ext. morph.
	4n	- " - (also 3n, 2n ?)	Mezhzherin and Pisanets (1995a, b)	chrom. count. and/or ext. morph.
46	3n	Pakistan, Karakoram, Sust, Hunza-Valley, 36°46'N, 74°50'E, 2950 m a.s.l.	Stöck et al. (1998, 1999)	chrom. count., flow cytom., and/or erythr. size, calls
47	3n	Pakistan, Karakoram, Pasu, Hunza-Valley, 36°30'N, 74°52'E, 2600-2800 m a.s.l.	Stöck et al. (1998, 1999), present paper	chrom. count., flow cytom., and/or erythr. size, calls
47a	3n	Pakistan, Northern Areas, Hunza-Valley, river bank, Karimabad near Ganesh, 36°18'N, 74°41'E, 2060 m a.s.l.	present paper	flow cytom.
48	3n	Pakistan, W-Himalayas, Upper Swat valley, Kulalai, 35°19'N, 72°36'E, 1750 m a.s.l.	Stöck et al. (1998, 1999)	chrom. count. only one specimen), and/or erythr. size, calls
48a	3n	Pakistan, Northern Areas, Gilgit, 35°54'N, 74°24'E, 1550 m a.s.l.	Stöck et al. (1998, 1999)	chrom. count., flow cytom., and/or erythr. size, calls
48b	3n	Pakistan, Northern Areas, Gupis, 36°14'N, 73°27'E, opposite Yasin valley, 2160 m a.s.l.	present paper	flow cytom.
48c	3n	Pakistan, Shandur Pass, Lake, border of NWFrontier Prov. and Northern Areas, 3720 m a.s.l.	present paper	flow cytom.
48d	3n	Pakistan, NWFrontier Prov., Hindu-Kush, Buni, approx. 36°20'N, 72°20'E, approx. 1900 m a.s.l.	present paper	flow cytom.
48e	3n	Pakistan, NWFrontier Prov., Hindu-Kush, Chitral City, 35°53'N, 71°47'E, 1480 m a.s.l.	present paper	flow cytom.
48f	3n?	Afghanistan, Kabul ?, 34°31'N, 69°12'E, sample not surely localized for Kabul	Bachmann et al. (1978): "36% more DNA than diploid <i>B. viridis</i> ", Hemmer et al. (1978)	microdens.
49	2n	Pakistan, Northern Areas (Baltistan), Himalaya, Satpara river SW of Skardu, 35°17'N, 75°37'E, 2300 m a.s.l., see also M and N	present paper	flow cytom., chrom. count
50 (?)	4n	China, Xinjiang: Hotan; localization in the present map not sure	Wu Min and Zhao Yajiang (1987)	chrom. count.
51	4n	Kyrgyzstan, Naryn	Stöck (unpublished)	chrom. count.
52	4n	Kyrgyzstan, Kara-Kudzhur-valley	Toktosunov (1984) and cited by Borkin et al. (1986a)	chrom. count.
52-57	4n	Kyrgyzstan, whole environs of Issyk-Kul, 1670 m a.s.l.	Mazik et al. (1976)	chrom. count.
	4n	- " -	Toktosunov (1984) and cited by Borkin et al. (1986a)	chrom. count.
	4n	- " -	Roth and Rüb (1987b)	chrom. count.
	4n	- " -	Borkin (1989)	partly chrom. count.
	4n	- " -	Mezhzherin and Pisanets (1995a, b)	chrom. count. and/or ext. morph.
	4n	- " -	Fikhtman (1989)	method not mentioned
53	4n	Kyrgyzstan, Chu-valley, approx. 20 km W Rybacha, near Kokmoyuk, approx. 1600 m a.s.l.	Stöck (1997a), Stöck and Grosse (1997a)	erythr. size
	4n	Kyrgyzstan, SW bank of Issyk-kul	Mezhzherin and Pisanets (1991)	method not mentioned

54	4n	Kyrgyzstan, Issyk-kul, N-bank near Sary-Kamysht, 1670 m a.s.l., 42°29' N, 76°20' E	Stöck (1997a), Stöck and Grosse (1997a), Stöck (1998a)	erythr size, calls
	4n	Kyrgyzstan, Issyk-kul	Castellano et al. (1998)	chrom. count., calls
55	4n	Kyrgyzstan, Issyk-kul, S-bank near Tamga, 1670 m a.s.l.	Stöck (1997a), Stöck and Grosse (1997a), Stöck (1998a)	chrom. count. of adults, erythr. size, calls
56	4n	Kyrgyzstan, Rayon Tyub, village Frunze	Borkin (1989)	partly chrom. count.
57	4n	Kyrgyzstan, NO-bank of Issyk-Kul, Rayon Tyub, near Kuturga	Borkin (1989)	partly chrom. count.
	4n	Kyrgyzstan, Issyk-kul, N-bank near Chon-Oryuktu, 1670 m a.s.l.	Stöck (1997a), Stöck and Grosse (1997a)	chrom. count. of adults, erythr. size
58	4n	Kyrgyzstan, Kemin-valley, 2500 m a.s.l.	Toktosunov (1984) and cited by Borkin et al. (1986a)	chrom. count.
59	2n	Kazakhstan, Almaty	Birstein (1981), Pisanets (1991)	chrom. count.
	2n	Kazakhstan, Almaty	Mezhzherin and Pisanets (1991)	method not mentioned
	4n	Kazakhstan, Almaty	Mezhzherin and Pisanets (1995a, b)	chrom. count. and/or ext. morph.
	4n	Kazakhstan, Almaty	Borkin et al. (1995)	flow cytometry
	4n	Kazakhstan, Almaty, 900 m a.s.l., 76°55' N, 43°15' E	Dujsebayaeva et al. (1997), Castellano et al. (1998)	chrom. count., calls
59a	2n	Kazakhstan, Kopa, 20 km S of Kopa station, 75°47' N, 43°25' E	Dujsebayaeva et al. (1997), Castellano et al. (1998)	chrom. count., calls
59b	4n	Big Almaty Lake, Zailiskii Alatau Range, 2300 m a.s.l., 77°N, 43°04' E	Dujsebayaeva et al. (1997), Castellano et al. (1998)	chrom. count., calls
60	4n	Kazakhstan, Kapchagay, Ili-river	Borkin et al. (1986a), Borkin et al. (1995)	chrom. count. and/or flow cytometry
60a	4n	Kazakhstan, Bashui, 1 km S Altyn-Emel Mountain Range 44°10' N, 78°45' E	Borkin et al. (1995)	flow cytometry
60b	4n	S foothills of the Koyandytau Mountain Range	Borkin et al. (1995)	flow cytometry
	4n	Ayan-Saz Point, Borokhudzir river valley, between Koyandytau and Dsungarian Alatau Mountains	Borkin et al. (1995)	flow cytometry
61	2n?, 4n	Kazakhstan, valley of river Chingzhal, basin of lake Alakol, 6-10 km near Andreevka	Golubev (1990)	method not mentioned
	4n	Kazakhstan, Andreevka	Mezhzherin and Pisanets (1995a, b)	chrom. count. and/or ext. morph.
	4n	Kazakhstan, Taldy-Kurganskaya oblast	Pisanets (1992b)	chrom. count., ext. morph.
	4n	Kazakhstan, Ucharal	Mezhzherin and Pisanets (1995a, b)	chrom. count. and/or ext. morph.
62	4n	China, Xinjiang, Wusu (Usu ?)	Wu Min and Zhao Yajiang (1987)	chrom. count.
63	4n	China, E-Tian Shan (E-Narat Shan), Künas 43°14' N, 84°40' E, 2145 m	Stöck (1998b)	chrom. count., calls
65	4n	Kazakhstan, Aksii-Farm, Zaysan-lake	Borkin et al. (1986a)	chrom. count.
	4n	SW-part of Zaysan-gorge, 12 km NW of settlement Maikapchagai near Aksii-Farm	Shcherbak and Golubev (1981)	method not mentioned
64	4n	China, Xinjiang, Wulumuqi (Ürümqi)	Wu Min and Zhao Yajiang (1987)	chrom. count.
66	4n	Mongolia, river Ded-Nariin-Gol, S-slope of Mongolian Altai, 2000 m a.s.l., 12 of the detailed map in:	Borkin and Kuzmin (1988)	mostly chrom. count.
67	4n	Mongolia, oasis Chug-Bulag, Bulgan-Somon, Chovd-Aimak	Borkin et al. (1986b)	chrom. count.
	4n	corresponds to 1, 2 and 3 of the detailed map in:	Borkin and Kuzmin (1988)	chrom. count.
68	4n	Mongolia, 60 km W of settlement Bulgan, Chovd-Aimak, river Bulgan-Gol	Meyer (1991)	ext. morph.
69	4n	Mongolia, spring Chujten-Bulak, S-slope of Mongolian Altai, 2000 m a.s.l., spring Bayan-Mod, 15 km N of spring Icher-Tol, 1600 m spring Icher-Tol, 83 km NW of settlement Bulgan, 1600 m a.s.l., spring Chavchig-Us or Chavchig-Bulag-spring Shara-Bulag	Borkin and Kuzmin (1988)	partly chrom. count.
70	4n	Mongolia, river Uench-Gol, 46°N.B., 92°W. L., 1350 m a.s.l. (11 of the detailed map in:	Borkin and Kuzmin (1988)	partly chrom. count.
	4n	Mongolia, spring Jaman-Usny-Bulag or Jaman-Us, 30 km E of settlement Uench, 1800 m a.s.l., 12 of the detailed map in:	Borkin and Kuzmin (1988)	partly chrom. count.
71	4n	Mongolia, oasis Ushigiin-Us, Dsungarian Gobi, 90 km SW of settlement Bulgan, 9 of the detailed map in:	Borkin and Kuzmin (1988), Orlova and Uteshev (1986)	partly chrom. count.
72	4n'	Mongolia, spring Domdzhiigün-Us, Dsungarian Gobi, 85 km S of settlement Bulgan, 10 of the detailed map in:	Borkin and Kuzmin (1988), Orlova and Uteshev (1986)	partly chrom. count.
73	4n	China, Xinjiang, Hami prefecture, 12 km NE Koumenzi, 2090 m a.s.l.	Zhao and Adler (1993)	ext. morph.
74	4n	China, Xinjiang, Hami	Wu Min and Zhao Yajiang (1987)	chrom. count.
A	?	Iran, Luristan, Shah Bazan, km 324 of the Transiranian railway, type locality of <i>Bufo (surdus) luristanicus</i>	Schmidt (1952, 1955), Schmidler and Schmidler (1969), Mertens (1971b), Eiselt and Schmidler (1973), see also Q. R. S.	no ploidy determination
B	2n?	Iran, NW part of Central Iranian Plateau, Cheshmeh-ye Sefied-Ab, type locality of <i>Bufo kavirensis</i>	Andrén and Nilson (1979), Stöck (1998a): diploid?, present paper	calls
C	2n	Iran, Kerman, type locality of <i>Bufo viridis kermanensis</i>	Eiselt and Schmidler (1971), Hemmer et al. (1978), present paper	chrom. count., flow cytometry
D	4n	Turkmenistan, Achgabadskaya oblast, Danata village, type locality of <i>Bufo danatensis</i>	Pisanets (1978), Borkin and Kuzmin (1988), see also number 5	chrom. count.
E	4n	E-Iran, Ssaman Shakh mountains near Birjand, type locality of <i>Bufo oblongus</i>	Nikolsky (1896, 1897), Eiselt and Schmidler (1973), Roth (1986), Borkin and Kuzmin (1988), present paper	chrom. count., flow cytometry
F	2n	Tadzhikistan, Dushanbe, type locality of <i>Bufo viridis turanensis</i>	Hemmer et al. (1978), Pisanets and Shcherbak (1979), Roth (1986), Borkin et al. (1986b), Kuzmin (1995, 1999), Mezhzherin and Pisanets (1995a, b), see also number 23	no ploidy determination of the type series

G	2n	Tadzhikistan, SW-part, Beshkent desert, near Shaartus, type locality of <i>Bufo shaartusiensis</i>	Pisanets (1991), Pisanets et al. (1996), Kuzmin (1999), see also number 29	chrom. count.
H	?	Pakistan, Pishin, type locality of <i>Bufo (viridis) zugmayeri</i>	Eiselt and Schmidtler (1973), Borkin and Kuzmin (1988), Stöck et al. (1999), Borkin et al. (2000)	no ploidy determination
J	3n and/or 4n (?)	Kyrgyzstan, Arslanbob, type locality of <i>Bufo viridis asiomontanus</i>	Pisanets and Shcherbak (1979: diploid without determination), Borkin and Kuzmin (1988), Borkin et al. (1997), Kuzmin (1999), Borkin et al. (2000)	chrom. count. (only one triploid specimen tested by Stöck, unpubl.), calls
K	4n	Kyrgyzstan, Kokmoinok, terra typica of <i>Bufo (viridis) unicolor</i>	Kashchenko (1999), Stöck (1997a), Stöck and Grosse (1997a), Kuzmin (1999), see also number 52 to 57	chrom. count.
L	4n	China, Kashgar, one of three type localities of <i>Bufo nouettei</i> sensu Mocquard; type locality of the <i>B. nouettei</i> lectotype	Mocquard (1910), Borkin and Kuzmin (1988), Stöck (1998b), additional papers are cited in the last one	chrom. count., calls, flow cytometry
M	2n	Pakistan, Shino village near Siachen glacier, type locality of <i>Bufo siachinensis</i>	Khan (1997), Baig (1998), Stöck et al. (1998, 1999): junior synonym of <i>B. latastii</i> , see N and 49	chrom. count., flow cytometry
N	2n	N-India, Ladakh, a locality was not exactly described, terra typica of <i>Bufo latastii</i>	Boulenger (1882: 295), Dubois and Martens (1977), Hemmer et al. (1978), Pisanets and Shcherbak (1979), Gruber (1981), Borkin et al. (1986a), Roth (1986), Borkin and Kuzmin (1988), Khan (1997), Baig (1998), Kuzmin (1999), Stöck et al. (1999), see M and 49	chrom. count., flow cytometry
O	3n	Pakistan, Swat valley, Mingora province, terra typica of <i>Bufo (viridis) pseudoraddei pseudoraddei</i>	Mertens (1971a), Pisanets and Shcherbak (1979), Roth (1986), Borkin and Kuzmin (1988), Baig (1998), Kuzmin (1999), Stöck et al. (1999), additional papers are cited in the last one	chrom. count. (only one specimen), calls
P	3n	N-Pakistan, Karakoram, type locality of <i>Bufo pseudoraddei baturoae</i>	Stöck et al. (1999)	chrom. count., calls, flow cytometry
Q	?	SE-Iran, Bazman, Tamin in Sarhad, Duz-Ab, Ziaret in Sarhad, type locality of <i>Bufo persicus</i>	Nikolsky (1899), Carvsky ("1925", 1926): "synonym of <i>B. surdus</i> ", Schmidt (1955), Schmidtler and Schmidtler (1969), Eiselt and Schmidtler (1973), see also R and S	no ploidy determination
R	?	Belutchistan (W-Pakistan?), not exactly localized, terra typica of <i>Bufo surdus</i>	Boulenger (1891), Carevsky ("1925", 1926), Schmidtler and Schmidtler (1969), Eiselt and Schmidtler (1973), see also Q and S	no ploidy determination
S	?	SW-Iran, Mehkuh, 70 km S of Shiraz, type locality of <i>Bufo surdus annulatus</i>	Schmidtler and Schmidtler (1969), Eiselt and Schmidtler (1973)	no ploidy determination
T	4n	China, type locality of <i>Bufo</i> ssp. <i>taxkorensis</i>	Fei et al. (1999), Stöck (1998b)	no ploidy determination in ssp. description, Stöck (1998b): chrom. count. (only one specimen), calls
U	?	China, Kok-Far (= Kokyar), type locality of the depicted specimen of <i>Bufo viridis</i> var. <i>pewzowi</i> ; three other type localities for the series	Bedriaga (1898: 61 and Fig. 2, plate 1), Hemmer et al. (1978), Borkin and Kuzmin (1988), Fei et al. (1999)	no ploidy determination
V	?	China, Tschik-Tym (= Qiktim), Turfan, type locality of <i>Bufo viridis</i> var. <i>grun-grzimailoi</i> ; "Turfan": one of 14 type localities of <i>Bufo viridis</i> var. <i>strauchi</i>	Bedriaga (1898: 61), Hemmer et al. (1978), Borkin and Kuzmin (1988)	no ploidy determination

First Record of the Smooth-Backed Parachute Gecko *Ptychozoon lionotum* Annandale 1905 from the Indian Mainland

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Abstract.—The smooth-backed parachute gecko, *Ptychozoon lionotum* is reported from the mainland India for the first time. The nearest known previous record was from Pegu, Myanmar, about 700 km southeast of the previous location. The species was collected in Langtlai and seen in the Ngengpui Wildlife Sanctuary, both in south Mizoram. The collected individual was kept in captivity for four and a half months. During this time, opportunistic observations on activity pattern, food habits, escape and parachuting behavior were made. Both individuals showed slow, deliberate pre-escape movement previously unrecorded for *Ptychozoon*. Information on morphological characters and morphometric measurements is presented. Explanations for the disjunct distribution are discussed.

Key words.—Reptilia, Gekkonidae, *Ptychozoon*, parachute gecko, Northeast India, Myanmar, distribution, biogeography, behavior

Ptychozoon is a genus of arboreal geckos distributed over much of Southeast Asia, primarily in moist tropical evergreen and semi-evergreen forests (Brown, 1999; Brown *et al.* 1997; Smith, 1935). At present, six species are recognized under the genus: *Ptychozoon kuhli*, *P. horsfieldii*, *P. lionotum*, *P. intermedium*, *P. rhacophorus* and *P. trinotaterra* (Brown *et al.*, 1997; Brown, 1999). To date, the only species reported for India is *Ptychozoon kuhli*, from the Nicobar Islands (De Rooij, 1915; Smith, 1935; Tiwari, 1961). We present here the first record of the smooth-backed parachute gecko *Ptychozoon lionotum* based on two records from the state of Mizoram (21°56'N to 24°31'N and 92°16'E to 93°26'E) in Northeastern India (Fig. 1).

The first individual was sighted on 29th June 1998 in Lawngtlai town of south Mizoram during a short survey. Subsequently, on 21st April 1999, a second individual was sighted by SP from the vicinity of Ngengpui Wildlife Sanctuary (NWLS; 22°21'24" N to 22°30'06" N and 92°45'12" E to 92°50'20" E) in south Mizoram, during a herpetofaunal community study (Pawar, 1999). We could only collect the first individual, and although SP could get a superficial look at the second one before it escaped (see below), we presume that it was the same species as the straight-line distance between the two sites is only about 40 km. Both the localities lie in the low to mid-elevation region of south Mizoram. The vegetation is of the tropical (moist) evergreen type, corresponding to Northern Tropical Evergreen Forest (1b/c2; Cham-

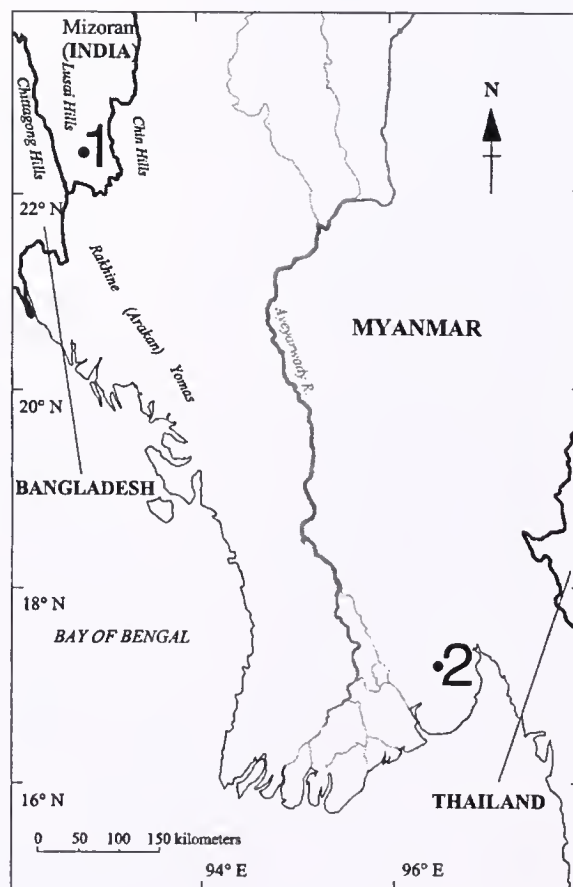


Figure 1. Present record (1) of *Ptychozoon lionotum* (BNHM 1445) from south Mizoram (India), along with nearest previous record (2) from Pegu (Myanmar).

Table 1. Mensural (in mm) and meristic measurements of two specimens of *Ptychozoon lionotum*. The vouchered record reported here (BMNH 1445) is compared with one of the syntypes (ZSI 2601). The latter specimen was fully discolored and severely mutilated so many characters were not discernable (NA) and so measurements beyond mm were not possible.

Character	BNHM 1445	ZSI 2601
Head length	16.8	15
Head width	16.8	16
Head height	12.7	11
Eye diameter	4.8	NA
Eye to nostril distance	8.2	NA
Eye to snout distance	11.3	11
Eye to ear distance	7.7	8
Inter orbital distance	10.3	NA
Inter narial distance	3.7	NA
Tympanum diameter	2.3	3
Neck length	11.9	NA
Snout to forelimb length	36.0	NA
Axilla to groin length	47.0	42
Body flap width (Greatest width from base of flap to tip)	8.1	9
Body flap length (From axilla to groin)	39.6	41
Fore arm length	18.7	12
Fore limb length	27.8	21
Femur length	13.6	NA
Tibia length	12.7	NA
Hind leg length	22.9	20
Hind foot length	39.6	37
Length of I st Toe	6.3	NA
Length of IV th Toe	9.4	NA
Snout to vent length	94.6	88
Tail length	93.0	NA
Tail width	7.6	NA
Tail depth	6.3	NA
Terminal tail flap length	20.1	NA
Terminal tail flap width	10.9	NA
Supralabials	10/11	NA
Infralabials	9/9	NA
Transverse dorsal bands in the axilla-groin region	4	NA
Number of lobes fused before straight flap	7	NA

Character	BNHM 1445	ZSI 2601
Supranasals in contact	No	NA
No. of tail lappets	19	NA
Subdigital lamellae (L/R)		
Finger I	11/10	NA
Finger II	11/13	NA
Finger III	12/16	NA
Finger IV	15/15	NA
Finger V	14/14	NA
Toe I	11/11	NA
Toe II	12/12	NA
Toe III	16/15	NA
Toe IV	14/14	NA
Toe V	14/14	NA

pion and Seth, 1968) and Chittagong Tropical Evergreen Forest (1b/c4; Wikramanayake *et al.* 1998).

Identification of the species as *P. lionotum* is based on the presence of the following combination of characters: absence of enlarged tubercle on the dorsum; denticulate tail lobes of the tail directed somewhat backwards; tail not tapering (Smith, 1935); presence of pre-digital notch on the forearm skin fold (Brown, 1999; Brown *et al.* 1997; Cox *et al.* 1998). We also compared our specimen with one of the syntypes of *P. lionotum* (ZSI 2601, from Pegu, Myanmar) and a specimen of *P. kuhli* (ZSI 2603, from Nicobar Islands) housed at the National Zoological Collection of Calcutta. Selected morphometric measurements (after Brown, 1999; Brown *et al.* 1997; Das, 1997; Ota, 1989; Zug and Moon, 1995) were recorded using Mitutoyo Digimatic callipers, with an accuracy of 0.1 mm (Table 1).

The color pattern of the specimen (in life) was as follows (Fig 2): Dorsally medium to dark gray with darker markings; dermal appendages lighter in color, mottled; distinct wavy dark, grayish-brown transverse bands present, four between the axilla and groin; chin and gular region dirty white to yellowish, white on chest, belly and underside of tail heavily powdered with gray-brown; underside of thighs, arms and dermal appendages was similar to gular region in color. The collected individual showed some degree of color change in captivity, ranging from light (bands distinct) to dark gray (bands barely distinct).

The individual was judged to be an adult female based on the absence of preanal and femoral pores

and the lack of hemipenal swellings at the tail base. The sex was later confirmed by dissection.

The individual was kept in captivity in a glass terrarium measuring 2x1x1.5 ft, for four and a half months. During this period, we frequently took the gecko out at different times of the day, which allowed us to make additional behavioral observations, including those on its escape and parachuting behavior. The specimen was later euthanized and preserved in 70 % ethanol after fixing in 10% formalin, and deposited in the reptile collection at the Bombay Natural History Museum (BMNH fide Leviton *et al.*, 1985) in Mumbai (No. 1445).

Natural History and Behavior

A mosaic of bamboo-dominated patches, remnant mature forest, teak plantations and jhum fallows of varying ages surround the town of Lawngtlai (900–1000 m elevation), where the first individual of *Ptychozoon* was seen. At 1930 hrs on 29th June 1998, the parachute gecko was seen in a circuit house situated in the outskirts of the town. It was resting on the inside ledge of a window in the corridor, at a height of about 2 m from the floor. The corridor was enclosed, the only entry points being the windows and the doors at the ends of the passage. In the same passage, there were a few *Hemidactylus frenatus*, while a nearby corridor was occupied by *Cosymbotus platyurus*. While resting, the dermal appendages of the parachute gecko were closely apposed to the body, and it did not show any movement, except for a vigilant but sluggish lateral movement of the body towards the outside of the ledge when attempts were made to capture it.



Figure 2. *Ptychozoon lionotum* (Adult female, BNHM 1445) from Mizoram, northeast India.

On 6th April 1999, SP, along with his field assistant, spotted the second *Ptychozoon* at 1820 hrs, next to a dirt track in a patch of mature evergreen forest south of NWLS boundary, ~40 km (straight-line) south of the first locality. NWLS is the only remaining patch of unfragmented, mature primary forest in the area, characterized by a three-tiered structure, with towering, buttressed, deciduous emergents up to 50–60m in height, followed by middle and tertiary canopy trees (Pawar, 1999). This area, especially the Ngengpui valley, experiences five rainless months, but the effective dry period is much shorter, with humidity being consistently high during these months due to fine, localized precipitation from cloud and fog. This individual was smaller than the first one and was spotted at a height of 5 m on the trunk of a *Sterculia scaphigera* tree. The tree is characterized by a deeply fluted trunk and a smooth but slightly flaking bark, and occurs as a deciduous canopy-emergent in pri-

mary evergreen forest above 500 m elevation. The patch of forest was on a slope at an altitude of approximately 450 m, and the tree (385 cm in girth at shoulder height) was towards the edge of the patch, slightly down slope, about 3 m from the dirt track and the observers. The gecko was sitting on the outer ridge of one of the trunk folds with its head pointing downward, barely visible on the lichen-covered bark. It was twilight, and upon sighting it, SP observed the animal for about a minute with the aid of a torch and binoculars before attempting to capture it. Meanwhile, the gecko had apparently become wary and steadily started moving laterally in the manner of the first individual away from the two observers, towards the other side of the trunk and out of sight. When SP tried to dislodge the gecko with a bamboo pole, the animal rapidly moved further around the trunk. It then jumped onto some lianas which were 2.5 m from the trunk, landed 1.5 m lower than its previous position with its head up, ran further up and vanished into a mass of dry branches which were caught in the lianas. All further attempts to trace the gecko were futile, and we presume that either the gecko jumped on to another tree or liana, or fell to the ground somewhere down slope when the lianas were shaken to dislodge it. *Hemidactylus frenatus*, *H. garnoti*, *Cosymbotus platyurus* and *Gekko gekko* are four other gekkonines that were commonly seen in the same area.

During its four months of captivity, the individual was offered a variety of insects, of which it took cockroaches and moths most readily. In the daytime, it remained motionless, either on one of the branches in its terrarium, or on one of the tar strips at the corners of the enclosure. Towards evening however, it would become active, and was often observed moving around the terrarium, making audible leaps across the corners of the enclosure. When taken out, its behavior was very different during day and night. If kept on a branch or tree trunk in the daytime, it would remain motionless with its limbs closely apposed to the trunk, and move only if provoked. If not disturbed for a long time, it would start moving slowly with the same slow, deliberate movement that it had displayed during its capture, either out of sight to the other side of the branch/trunk, or run up the tree. In the evenings however, it showed much more alacrity in trying to escape, often with the same preliminary lateral movement of its body. On two occasions it also resorted to launching itself into the air, and when it fell to the ground, remained motionless. This escape behavior has been earlier observed in these geckos, and remaining immobile ostensibly makes it difficult to locate them (Brown *et al.*, 1997). However, the slow pre-

escape movement that we observed in both the specimens has not been reported before, and we reason that this behavior probably aids the gecko to position itself for parachuting or simply move out of sight (such as the blind side of a tree trunk) inconspicuously, without disclosing its crypsis. To gain further insights into this escape behavior that we observed in both the specimens, we dropped the individual on seven occasions from heights of 3–5 m and observed its behavior. In all instances, the dermal appendages came into play apparently due to air resistance, and the gecko dropped relatively softly on the ground without any horizontal displacement.

The ecology and behavior of species of *Ptychozoon* is poorly known, and there has been much discussion about its alleged ability to “glide” (Günther, 1864; Smith, 1935; Tiwari, 1961 and references therein). It has been argued that the dermal appendages do not help in gliding, but enhance its camouflage. However, experimental studies have now demonstrated that the dermal appendages do allow the gecko to take advantage of air resistance while making long sallies (Heyer and Pongsapipatana, 1970; Marcellini and Keefer, 1976) and may serve a dual function in crypsis and escape or locomotion (Marcellini and Keefer, 1976). Recently, Brown *et al.* (1997), based on their observations of the escape behavior of *P. intermedium* in the wild, have argued that “parachuting” is a more appropriate term than “gliding” to describe this behavior in these geckoes. Our observations apparently sustain the arguments of Brown *et al.* (1997). Further studies on the preflight behavior of *Ptychozoon* species may provide interesting insights into the escape behavior of this extraordinary group.

Biogeographical Notes

The syntype (ZSI 2601), collected by Major Beddome and W. Theobald from Pegu in south Myanmar, was previously the northwestern most distribution record of *Ptychozoon* (Annandale, 1905; Brown *et al.* 1997). The present record thus adds a crucial link to the distributional information for the genus, and increases the known range ca.700 km towards the northwest. This also adds another case of range disjunction in a region that already has numerous examples of taxa showing dramatic discontinuities in their range (Mani, 1974).

After the collision of the Indian plate with the Asian mainland in the Eocene (54–36 mybp) (Molnar and Tapponnier, 1975), Indo-Malayan faunal and floral elements have colonized different parts of the India, resulting in more Indo-Malayan faunal representatives within India than vice versa (Das, 1996; Mani, 1974). Geckos are notorious for their penchant

for waif-dispersal (Case *et al.* 1994). It has been observed that *Ptychozoon* species are not obligate forest dwellers (Annandale, 1904; Brown *et al.* 1997), and probably are capable of dispersing through both forest and human inhabited areas (Annandale 1904; Brown *et al.* 1997).

Mizoram is dominated by the Lushai Hills, a series of parallel hill ranges running from north to south and increasing in elevation from west to east (Pachuau, 1994). To the west of these hills lie the Chittagong Hill tracts of Bangladesh, and to the east lie the Chin Hills and the Arakan Yoma mountain ranges of Myanmar. The latter, also running in a north-south direction, lie between the lowland moist evergreen forests of south Mizoram and Pegu. Along the foothills of the Arakan Yomas, flanking the western side, lie more or less contiguous rainforests, which forms a habitat bridge between these two areas (Collins *et al.* 1991). It is likely that this species has extended its range northwards along this route. This conjecture will get firmer footing if surveys in these forests reveal the presence of *P. lionotum* along these tracts. The areas beyond the Lushai Hills of Mizoram and the adjoining Chin Hills of Myanmar in contrast, are more arid with relatively dry forests. Moreover, recent surveys have not revealed the presence of *Ptychozoon* species in these areas, and it is unlikely that it exists there (George Zug, *pers. comm.*).

Our inquiries revealed that not many local people know of this gecko, but those who did, opined that it was rarely seen because it mostly “lived high up in the trees”. There have also been unconfirmed reports of a parachute gecko from north Mizoram (Lal Ramthanga, *pers. comm.*). That this area has been inadequately surveyed is evident from the fact that the six-month herpetofaunal study conducted by SP yielded a number new taxa and distributional records (Pawar, 1999). Further exploration will probably reveal that *Ptychozoon* is present in other parts on this region, and its range may not be as disjunct as it appears now.

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cal comments and literature. Aysegul Birand helped prepare the map for Fig. 1.

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A New Species of *Eremias* (Sauria: Lacertidae) from Highlands of Kermanshah Province, Western Iran

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Abstract.— A new and distinctive species of the genus and subgenus *Eremias* is described from the highlands of Kermanshah Province, western Iran at about 1800 m elevation. It is easily distinguished from all other species of the typical subgenus (*E. velox*, *E. persica*, *E. strauchi*, *E. nigrolateralis*, *E. lalezharica*, *E. afghanistanica*, *E. regeli*, *E. suphani*, and *E. nikolskii*) by a variable number of postmentals (4–5 pairs), smaller size, and distinctive color pattern. Furthermore, it can be distinguished by having a combination of characters against any of the species in the typical subgenus. Systematics of the genus and subgenus *Eremias* is shortly discussed.

Key words.— Lacertidae, *Eremias*, *Eremias (Eremias) montanus*, Western Iran, Zagros Mountains, Kermanshah province, Siah-Darreh



Figure 1. Location of Kermanshah province on the Iranian Plateau.

Introduction

The lacertid genus *Eremias* Fitzinger, 1834 encompasses about 33 species of mostly sand, steppe, and desert dweller lizards which are distributed from northern China, Mongolia, Korea, Central and south-west Asia to southeastern Europe (Rastegar-Pouyani and Nilson, 1997). The genus is Central Asian in its relationships and affinities (Szczerbak, 1974). About 15 species of the genus *Eremias* occur on the Iranian Plateau mostly in northern, central, and eastern regions (Rastegar-Pouyani and Nilson, 1997; Anderson, 1999). To date, no comprehensive study has been carried out on *Eremias* fauna of the Iranian Plateau and the systematic status of most taxa is in great need of a revisionary work. Szczerbak (1974), however,



Figure 2. The type locality of *Eremias (Eremias) montanus*, vicinity of the Village of Siah-Darreh, about 60km northeast of the city of Kermanshah, Kermanshah Province, western Iran.

revised *Eremias* and divided it into two distinguished genera based on morphological characters: *Mesalina* Gray and *Eremias* Fitzinger (see under *systematic discussion*).

As the first record of *Eremias*, in this paper we describe and introduce a new species of this genus from the upland and mountainous regions of Kermanshah province, western Iran at about 1800 m elevation. This province is located on the western periphery of the Iranian Plateau (Fig. 1) and a major part of it is covered by the Zagros Mountains. The type locality of *Eremias (Eremias) montanus* (sp. nov.) is located in an upland area surrounded by the Zagros Mountains

with steppe vegetation (e.g., *Astragalus*, *Euphorbia*, *Zygophyllum*), about 60 km northeast of city of Kermanshah, Kermanshah province, western Iran (Fig. 2).

***Eremias montanus*, new species (Figs. 3-4)**

Holotype and type locality: An adult female, Field number P198, collected by the senior author on 14 August 1995 from the upland regions of the Zagros Mountains, 60 km northeast of city of Kermanshah (47° 5'E, 34° 52'N), Kermanshah Province, western Iran, at about 1800 m elevation

Paratypes: Two adult females, Field number P199-P200, other information as for the holotype.

Diagnosis and comparison: A small-sized lacertid, maximum snout-vent length (SVL)= 57.2mm, tail length = 95mm, with 13-14 longitudinal and 27-28 transverse rows of ventral plates, slightly converging posteriorly; with 63-67 small, granular scales across

middle of dorsum. A species belonging to the subgenus *Eremias*: subocular reaches mouth edge; one frontonasal; two supraoculars which are not completely separated from frontal and frontoparietals; distance between the femoral pores being narrow; color pattern "striped"; inhabitant of steppe and mountain-steppe landscapes (Szczerbak, 1974: 83).

On the other hand, it differs from all other species of its relevant subgenus based on having several distinguishing characters; the color pattern is distinctive and it is distinguishable from all other species in this character i. e., dorsum uniformly dark-brown without spots and ocelli, interrupted by five light longitudinal stripes; the vertebral stripe bifurcating on the nape, two paravertebrals on each side; a broad dorso-lateral stripe containing one or two regularly arranged light spots (different from the other *Eremias* species in this character); Furthermore, it differs from each species of the typical subgenus in the following character combinations (Bischoff and Bohme, 1980; Bohme and Szczerbak, 1991; Rastegar-Pouyani and Nilson, 1997; Szczerbak, 1974):

From *Eremias nigrolateralis* Rastegar-Pouyani and Nilson, 1997 in having a much smaller size, lack of separation of the third pair of submaxillary shields by granular scales (0% versus 100%), lower count of gulars (23-24 versus 41-42), variable number of submaxillary shields (33% versus 0%), reach of femoral



Figure 3. *Eremias (Eremias) montanus* holotype.



Figure 4. *Eremias (Eremias) montanus* paratypes.

pores to the knee (100% versus 0%), and distinct differences in color pattern.

From *Eremias persica* Blanford, 1874 in having a smaller size, lower count of gulars (23-24 versus 28-38), the absence of distinctly keeled upper caudal scales (100% versus 75%), variable number of submaxillary shields (33% versus 4%) and distinct differences in color pattern.

From *E. velox* (Pallas, 1771) in having a smaller size, in the absence of distinctly keeled upper caudal scales (100% versus 0%), variable number of submaxillary shields (33% versus 5%) and in color pattern.

From *E. strauchi* Kessler, 1878 in having a smaller size, the absence of distinctly keeled upper caudal scales (100% versus almost 0%), variable number of submaxillary shields (33% versus 9%) and in color pattern.

From *E. laezharica* Moravec, 1994 in having variable number of submaxillary shields (33% versus 0%), higher count of dorsals (63-68 versus 54-59), no contact of gulars with the second pair of submaxillary shields, lack of a small scale between prefrontals, and distinct differences in color pattern.

From *E. afghanistanica* Bohme and Szczerbak, 1991 in a much higher count of dorsal scales (63-68 versus 44-46), lower count of gulars (23-24 versus 25-28), variable number of submaxillary shields (33% versus 0%), and in color pattern.

From *E. nikolskii* Bedriaga, 1905 in a higher count of dorsals (63-68 versus 45-59), variable number of submaxillary shields (33% versus 8%), and in color pattern.

From *E. regeli* Bedriaga, 1905 in a higher count of dorsals (63-68 versus 43-61), higher number of scales in the 9th-10th caudal annulus (27-28 versus 17-25), the absence of distinctly keeled upper caudal scales (100% versus 0%), variable number of submaxillary shields (33% versus 3%), and in color pattern.

Description of holotype: An adult female, preserved in 75% ethyl alcohol in good condition; body small and moderately depressed; a species of the subgenus *Eremias* (Szczerbak, 1974:83); five pairs of submaxillary shields, first three pairs in contact, the fourth and fifth pairs widely separated; first pair of submaxillary shields as large as the fifth and in contact with mental anteriorly, with first and second infralabials laterally; the fifth submaxillary pair each in contact with the fourth pair anteriorly, being surrounded by 8 granular scales laterally and posteriorly; 7-8 supralabials, 4-5 of which anterior to subocular which borders the

mouth; two large nasals in contact with rostral anteriorly, with first and second supralabials laterally, and with frontonasal and first loreal posteriorly, the former being single, broader than long and laterally in contact with first loreal and posteriorly with prefrontals; two prefrontals each smaller than frontonasal and almost as long as broad and laterally in contact with second loreal and posteriorly with frontal and granules of supraocular region; only frontonasal with distinct concavity; frontal almost as long as prefrontal and frontonasal together, broadened and posteriorly and laterally partly in contact with supraoculars (and partly separated from the latter by 2-3 large scales, not by granules) and posteriorly with frontoparietals; two frontoparietals almost as large as a single supraocular, laterally being in contact with the second supraocular, and posteriorly with interparietal and parietals, the former being small and relatively lozenge-shaped, surrounded by frontoparietals and parietals; two very large and plate-like parietals, almost as long as broad, being in contact behind interparietal; a vestigial occipital; two loreals, first one small, surrounded by first two supralabials, nasal, frontonasal, and the second loreal which is distinctly large with an evident keel; 6-6 supraciliaries, separated from supraocular by a series of 42-44 granules; postocular elongate, surrounded by granules anteriorly; temporal region mostly covered by granular scales becoming large towards the orbit, more than 100 on each side; tympanic scale distinct and elongated obliquely, almost the same size on both sides; tympanum vertically elongated, slightly larger than orbit; no distinct supratemporal; subocular huge, broader than long with a distinct ridge being extensively in contact with the lower edge of orbit; lower eyelids with a semi-translucent membrane made up of about 22 enlarged scales; collar well pronounced, not serrated, made up of 10 scales, the two medial ones the largest; gular fold weakly developed, 23-24 gulars from symphysis of chin shields to median gular, becoming enlarged posteriorly; 13-14 longitudinal and 27-28 transverse rows of almost squarish ventral plates from collar to hindlimbs; anterior series of ventrals to some extent irregular, median ventral longer than broad; dorsal scales juxtaposed, smooth, granular, becoming slightly larger posteriorly, 63-68 scales across the middle of dorsum, and about 160-164 scales in a single row from occiput to a point just above the vent; proximal caudals larger than posterior dorsals but the change being gradual; caudals becoming large, elongate, and slightly keeled distally, arranged in distinct whorls, 27-28 scales in the 10th whorl behind the vent; upper forearm covered dorsally by enlarged, juxtaposed, and almost lozenge-shaped scales; lower forearm covered

with granules; upper hindlimbs covered externally by granules, externally by large shields; tibia covered dorsally by slightly pointed granules, ventrally by large plates which are slightly keeled, two plates in a transverse row; no fringes on the toes, 18-20 uni- and bi-carinate lamellae under fourth toe, proximal part of lower fourth toe containing two complete rows of lamellae, distal part with a single row (in this character it is quite different from all other species of its relevant subgenus); 18-19 femoral pores in each side, the two series separated anteriorly by a narrow space consisting of three scales; preanal region encompassing 24 large shields, the four median ones being the largest; 6 plates in longitudinal row from the space between femoral pores to anterior edge of the vent.

Coloration and color pattern: Dorsum uniformly dark-brown without spots and ocelli, interrupted by five light, narrow longitudinal stripes: one vertebral bifurcating on the nape, two paravertebrals on each side; a broad dorso-lateral stripe containing one or two regularly arranged light spots; a ventro-lateral series of dark-brown spots, to some extent forming a stripe; upper surface of head uniformly olivish-brown; temporal and labial regions suffused by dark-brown; submaxillary region light-gray-cream; ventral region dirty white, suffused by bluish-brown; upper surface of limbs dark-brown containing numerous light spots; proximal upper surface of tail brown, distal part light brownish-gray; lower surfaces of limbs and tail yellowish-white.

Description of paratypes: The paratypes, two adult specimens, one male (P199) and one female (P200) approximate the holotype in almost all pertinent details. However, there are some minor differences between paratypes and the holotype as follows:

Male paratype: five submaxillary shields on the right side but only four on the left, the fifth vestigial; 13-14 longitudinal and 30-31 transverse ventral plates; 10-11 collars, 3-4 median ones the largest; 23-24 gulars in a longitudinal row from chin shields to collar; 20-20 femoral pores, separated by three small scales; 23-24 lamellae under fourth toe; 23-27 scales around 10th tail annulus; 8-9 labials, 5 of them anterior to subocular; 6-6 lower labials; lower nasal resting on the first two supralabials; temporal scale vestigial; 62-63 scales around widest part of dorsum; 162-167 scales in a single longitudinal row from occiput to vent.

Measurements (mm): SVL = 58.5; TL = incomplete; Forelimb = 24; Hindlimb = 39; HL = 15.5.

Female paratype: only four pairs of submaxillary shield, the fifth vestigial; 15-17 longitudinal and 31-

33 transverse rows of ventral plates; 9 collars, 4-5 median ones the largest; 24-25 gulars in a single longitudinal row from chin shields to collar; 20-20 femoral pores, separated by a space corresponding to two scales; 25-26 scales on the 10th tail annulus, 24-25 subdigital lamellae under fourth toe; 8-9 supra- and 4-6 infralabials; temporal scales relatively small; frontal separated from the first supraocular by two large scales (not by granules); 65-67 scales around widest part of dorsum; 163-167 scales in a single longitudinal row from occiput to vent.

Measurements (mm): SVL = 52.9; TL = incomplete; Forelimb = 23; Hindlimb = 35.5; HL = 13.6.

In color pattern they are quite similar to the holotype.

Habitat: During field work on the western regions of the Iranian Plateau in 1995, we surveyed the Zagros Mountains and the nearby mountain steppes in the northern parts of Kermanshah province, 60 km north-east of Kermanshah city, in the highland steppes, in vicinity of the Village of Siah-Darreh in an area named Sarpal, we came across to three specimens of a new taxon of the genus *Eremias*, described here as a new species. The habitat, which is surrounded by the Zagros Mountains, is characterized by a mountain-steppe; the vegetation is luxuriant steppe association: mainly *Astragalus*, *Euphorbia*, *Artemisia*, and *Amigdalus* as well as various species of the families Gramineaceae and Compositae (Fig. 5).

Since it is a mountainous region with relatively high elevation, the winter being harsh and cold, the summer being mild and rather short. All the specimens were foraging around the shrubs probably looking for prey. They were quite shy and wary and very difficult to capture. When alarmed, they took refuge under the shrubs or inside the underground holes. One of the most effective anti-predatory adaptations evolved in these lizards is the ability to lose the tail (autotomy) when being touched by the predators (or collectors). Hence, we could only collect one specimen with a complete tail and the other specimens lost their tails during capturing.

In September 1998, we re-surveyed the type locality in order to find more specimens of this species but without success. Whether it being a relictual and rare species, confined only to the type locality, or being distributed over a wider area in the western margin of the Iranian Plateau is yet to be established.

With regard to the occurrence of *Eremias montanus* in the highlands of Kermanshah province, the Procter record of *E. velox*, as the westernmost record, from Kuretu (Iran-Iraq border) (Procter, 1921:252) should seriously be reconsidered.



Figure 5. Habitat and type locality of *Eremias (Eremias) montanus*. 60 km northeast of Kermanshah, vicinity of Siah-Darreh village, Kermanshah Province, Western Iran.

Etymology: *Eremias montanus* is so named as it is apparently restricted in distribution to the upland and mountainous steppes of northeastern regions of Kermanshah province, western Iran.

Taxonomic account: As mentioned before, so far, the most complete work done on the complicated genus of *Eremias* (sensu lato) is of Szczerbak (1974) who studied almost all species and species complexes of this genus throughout the range. Based on morphological characters and geographic distribution, Szczerbak (1974) subdivided the inclusive genus *Eremias* (s. l.) into two distinct genera; the genus *Mesalina* as a north African and lowland southwest Asian clade, and the genus *Eremias* (sensu stricto) which is mainly occurring in Central and northeast Asia. (Szczerbak, 1974).

Furthermore, Szczerbak (1974) subdivided *Eremias* (s.s) into five distinct subgenera: *Eremias* (Szczerbak, 1974: 83), *Rhabderemias* (Szczerbak, 1974: 201), *Ommateremias* (Szczerbak, 1974: 146), *Pareremias* (Szczerbak, 1974: 22-23), and *Scapteria* (Szczerbak, 1974:247).

Except for the subgenus *Pareremias*, which is a Central and east Asian clade, all of the major species groups of the genus are presented on the Iranian Pla-

teau (Anderson, 1999). Arnold (1986) who studied the hemipenes of lacertids supported the Szczerbak's subgeneric names. In a more recent study Arnold placed *Eremias* as the sister taxon of a clade including *Acanthodactylus*, *Mesalina*, and *Ophisops-Cabrita* (Arnold, 1989:238, 240). But Mayer and Benir (1994) have proposed a different scenario. According to these authors, *Eremias* is the sister taxon of *Mesalina* and both of them belong to a larger clade also containing *Omanosaura* and *Ophisops*. They believe that *Eremias* is not closely related to *Acanthodactylus*.

The Czech Biological Expedition to Iran in 1996 collected 8 specimens of an undetermined species of *Eremias* related to *E. persica* from the Zagros Mountains in Esfahan province at about 2000-2200 m elevation (Frynta et al., 1997: 9-10). Whether it is a new taxon or just a variety of *E. persica* is yet to be known.

Material examined: *Eremias montanus* (n = 3): P 198-200 (Field number), from around the Siah-Darreh Village (about 1800 m elevation), 60 km northeast city of Kermanshah, Kermanshah province, western Iran.

Eremias nigrolateralis (n = 2): GNHM. Re. ex. 5147-5148, from 150 km northeast of Shiraz, Fars province, south-central Iran.

Eremias persica (n = 4): GNHM. Re. ex. 5159-5162, from 150 km northeast of Shiraz, Fars province, south-central Iran.

Eremias persica (n = 28): GNHM. Re. ex. 5163-5190, from 45 km east of Arak on the road to Qum, Markazi province, north-central Iran.

Eremias persica (n = 4): GNHM. Re. ex. 5191-5194, from 65 km west of Tehran, between Eshtehard-Saveh, Tehran province, northern Iran.

Eremias persica (n = 2): GNHM. Re. ex. 5195-5196, from 45 km east of Golpaygan, Esfahan province, central Iran.

Eremias persica (n = 4): GNHM. Re. ex. 5197-5200, from 50 km north of Delijan on the road to Qum, Markazi province, north-central Iran.

Eremias persica (n = 1): GNHM. Re. ex. 5201, from 50 km north of Abadeh, Fars province, south-central Iran.

Eremias persica (n = 1): GNHM. Re. ex. 5202, from 50 km east of Hamedan on the road to Qazvin, Hamedan province, western Iran.

Eremias persica (n = 3): GNHM. Re. ex. 5203-5205, from 5 km west of Takestan on the road to Zanjan, Zanjan province, northwestern Iran.

Eremias velox (n = 4): GNHM. Re. ex. 5122(1-4), from around the Carin River, 250 km E-SE Almaty (Alma Ata), Kazakhstan.

Eremias velox (n = 2): GNHM. Re. ex. 5120 (1-2), from Mulali Kurozek, eastern Kazakhstan.

Eremias velox (n = 2): GNHM. Re. ex. 5121(1-2), from the Taldi Korgau District, northeast Kazakhstan.

Eremias velox (n = 2): GNHM. GK. 18881 (1-2), from Archenjan Village (1), and 30 km north of Mary (2), Turkmenistan.

Eremias strauchi (n = 3): GNHM. Re. ex. 4411 (1-3), from Golestan National Park, Mazandaran province, northeastern Iran.

Abbreviations : GNHM. Re. ex. = Gothenburg Natural History Museum, Reptilia exotica; GNHM. GK. = Gothenburg Natural History Museum, General Catalogue.

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Lizards of the Northern Mongolian Deserts: Densities and Community Structure

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Abstract.— Spatial organization and population densities of three-species lizard community was studied in the Gobi Desert, Mongolia. To evaluate the effect of habitat variables on the distribution and abundance of each species we used the stepwise procedure of factor selection with ANOVA on each step. To describe the distribution of species' spatial niches in the space of environmental variables, we used stepwise discriminant function analysis (DFA). The number of species in 1-ha grid areas varied from 0 to 4. *Phrynocephalus versicolor* was the only species distributed over the 91% of grids occupied. There was a positive relationship between distribution and local species abundance. A set of two to three habitat variables determined the abundance of each species. The result of DFA signify to the well pronounced segregation, but not even distribution of species spatial niches in the space of resources.

Key words.— Lizards, Mongolia, community, ecology, density

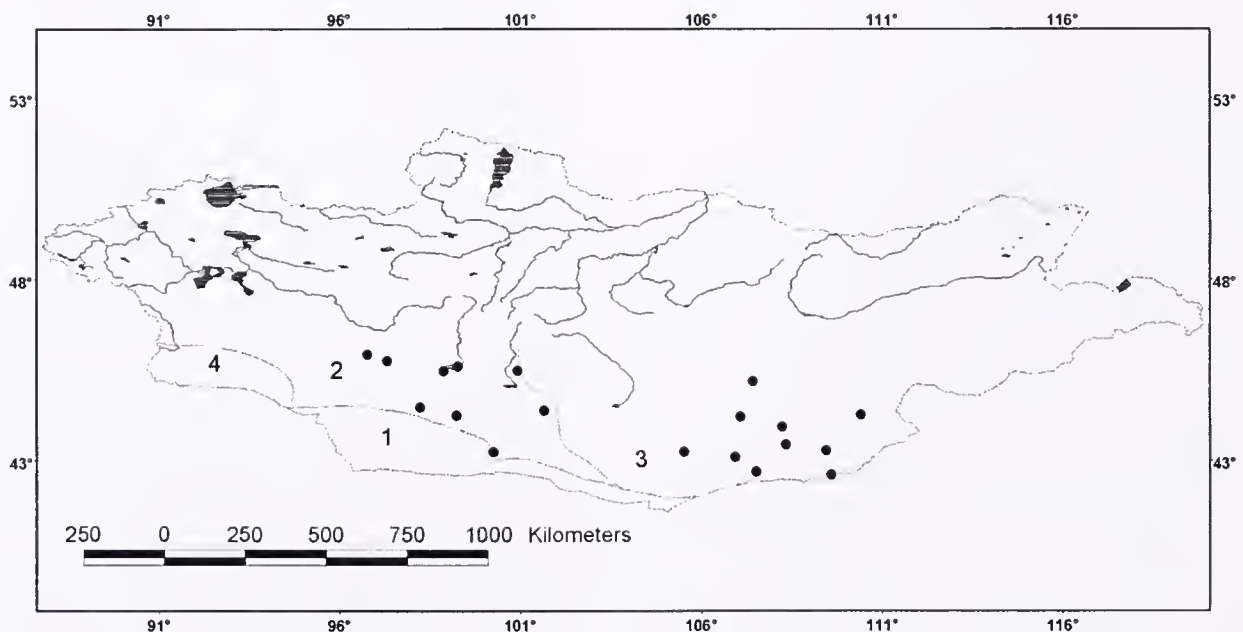


Fig 1. Map of Mongolia and location of sites where data were collected. 1 - Southern Gobi, 2-Western Gobi, 3-Eastern Gobi, 4-Barun-Churay Basin.

Introduction

The reptile communities of Mongolian deserts are characterized by several specific features discussed elsewhere (Ananjeva and Semenov, 1986; Borkin and Semenov, 1984; Munkhbajar, 1976; Semenov and Borkin, 1986; Semenov and Shenbrot, 1988). There are few species in the fauna with low species richness

at sites, a low level of species turnover between habitats, low abundance of most species and high dominance of only one species, *Phrynocephalus versicolor*. A few common species have rather broad spatial niches, diverse behavioral and physiological characteristics (diverse range of thermobiological patterns, wide active search for food items, etc.).

The degree of interest in comparative studies of structure and function of reptile communities increased dramatically after seminal papers written by E. Pianka (Pianka, 1973, 1975). Most of the ensuing studies were devoted to the species rich and diverse communities of desert lizards in Australia, southwestern North America and southern Africa (Case, 1983; Fuentes, 1976; Henle, 1989; Inger, Colwell, 1977; Millado et al., 1975; Pianka, 1986; Scheibe, 1987; Shenbrot et al., 1992; Simbotwe, 1984). At the same time study of species poor communities in the Central Asian desert can provide a significant information not only in comparison with other continents, but also can help us to understand better which factors rule in reality structure and dynamic of lizard communities of many species. Up to now there were only two examples of such studies made in China (Chang et al., 1993; Lui et al., 1992).

The main objective of this paper was to study the specific features of spatial organization and population densities of three-species lizard community in the Gobi Desert, Mongolia. The study was conducted during a long-term research program on the biodiversity of the Mongolian desert biota, and was sponsored by the Permanent Soviet-Mongolian Biological Expedition.

Material and Methods

Mongolian desert

A map (Fig. 1) illustrates the location of desert regions of Mongolia. Three desert regions to the south of the Altai Mountains are partly separated from one another by chains of low mountains and hills. These three are Trans-Altai Gobi (South), Alashan Gobi (East) and Sungarian Gobi or Barun-Churay Basin (West) (Yunatov, 1950). Besides these deserts there are desert areas between the Altai and Hangai mountains, usually called Western cold deserts, and some arid lands in the Great Lakes and Ubsu-Nur Basins (northwest).

Three arid subzones of the Mongolian desert are defined (Sokolov and Gunin, 1986): extra-arid desert (<50 mm of rainfall per year), real desert (50---100 mm per year) and steppe-like desert (100---150 mm per year). However, the climatic border that restricts the distribution of plants (Kazantseva, 1986; Volkova et al., 1986) and animals (Podtyazhkin and Orlov, 1986; Semenov and Borkin, 1986) exists only between the southern part of Trans-Altai Gobi (< 50 mm per year) and the northern waste belt of desert lands with more predictable precipitation (100-200 mm per year). The narrow real desert subzone appears

transitive with no specific features of vegetation. Thus, only the southern (extra-arid) and northern subzones are well pronounced.

The southern desert occurs mostly in the Trans-Altai Gobi and is characterized by a few very dry, unproductive biotopes inhabited by five lizard species (two agamids, two gekkonids, and one *Eremias* species). Among this group only one species, *Phrynocephalus versicolor* is common in the northern subzone (Semenov and Borkin, 1986).

The northern deserts, which extend to the southwest, west, and south-east of Mongolia and along both slopes of the Mongolian Altai and Gobi-Altai mountains, are characterized by pronounced microrelief and rich vegetation, although the main landscape types are the same as in the southern subzone. The vegetation in rock and gravel valleys consists of perennial grass (*Stipa*), forbs, onions and succulents, and a variety of annual plant species. Shrub vegetation is often associated with foothills and sand dunes, or is spread along the dry river beds (Lavrenko, 1978). The difference in climate between western and eastern parts of the northern Mongolian desert is not pronounced (Murzaev, 1952); some differences exists in the composition of the flora (Yunatov, 1950).

Lizard species

There are four lizard species inhabiting northern Mongolian deserts: *Alsophylax pipiens*, *Phrynocephalus versicolor*, *Eremias przewalskii* and *E. multiocellata*. Among these, only the three last mentioned species are abundant and relatively widespread.

Data collection

We collected data during three field trips to the Mongolian northern deserts in June-August 1985, 1986 and 1988. Forty five 1-ha grids were established in the Northern desert subzone (see map, Fig 1). Grids were distributed so that they covered the whole range of habitats from the middle slopes of the mountains to the clay basins and sand dunes. Each habitat type was sampled equally. Two factors determined the number of grids at a desert region: diversity of habitat types and abundance of lizards. Each grid was divided into 25 smaller sample plots, 20 x 20 m. The centers of sample plots were marked with 50 cm aluminum stakes. Lizards were sampled by repeated, regular search of established grids during two to four consecutive days during periods of their maximal diurnal activity. Nearly all encountered lizards were captured by hand. Most of the surveys accounting were conducted before the appearance of hatchlings. In the rest of the cases hatchlings were not counted. Each cap-

Table 1. Density (no. ha⁻¹) of lizard species.

Lizard species	Mountain slopes	Stony foothills	Stony and gravel planes	Sandy-loam plains	Clay hollows	Loess hills in saline depressions	Sand hills
<i>P. versicolor</i>	1.7±0.9 0 - 3	52.8±8.9 24 - 91	54.4±8.7 32 - 83	36.6±8.2 10 - 106	5.5±4.5 1 - 10	41.2±6.3 22 - 64	0.8±0.4 0 - 3
<i>E. przewalskii</i>	0	0	0	2.6±1.3 0 - 18	0	16.3±6.3 0 - 44	0.9±0.5 0 - 4
<i>E. multiocellata</i>	0	2.1±1.3 0 - 12	0.4±0.4 0 - 2	0.5±0.4 0 - 5	0	2.0±1.8 0 - 11	0

tured lizard was marked by toe-clipping (the most distal phalange only) and/or by a number painted with permanent color marker on its back, and released. Densities of lizard species were estimated by the total number of animals caught on a grid. The reliability of density estimates was verified by recapture of marked individuals and by the observation of marked lizards on grids. Two days were sufficient to catch > 80% of lizards.

A 0.5 kg soil sample was taken from the center of each plot for laboratory texture analysis. The number of shrubs (by species) in each plot was counted in a circle, 5 m in radius. To determine vegetation cover and volume by height layers within each plot, the height and diameter of crown of the shrubs (up to 30 shrubs of each species in the grid) were measured. The abundance of annuals was evaluated by clipping all annuals on 0.25 m² sample plots (4 sample plots placed at random in each of 25 plots in 1-ha grid area). Twenty three parameters were used in the subsequent analysis (Table 2). Data on 1125 descriptions of sample plots and 1710 records of 3 lizard species were used in the analysis. In total, we recorded 1528 individuals of the agamid lizard *P. versicolor*, 142 of the lacertid lizard *Eremias przewalskii* and 40 *E. multiocellata*.

Statistical data processing

To evaluate the effect of habitat variables on the distribution and abundance of each species we used the stepwise procedure of factor selection (Shenbrot, 1988) with ANOVA of each step. Before analysis, the original values of species' densities and habitat variables were transformed to an interval scale with five intervals for habitat variables and three intervals for species' abundance variables. The influence of each variable was estimated separately by ANOVA and the variables with nonsignificant effect were omitted. In the next step, each of variables that was not omitted earlier was added separately to the most powerful variable to select the most powerful pair of variables. This procedure was repeated until all possible variables were included in the analysis or until the addition of the new variable does not increase the proportion of explained dispersion.

To describe the distribution of species' spatial niches in the space of environmental variables (ecological space) and to reduce the dimensionality of this space, we used stepwise discriminant analysis. Discriminant axes were calculated based on the data set consisting of the values of habitat variables for each point of lizard's registrations and with lizard species as a grouping variable.

Results

Densities and distribution through habitat types

The results of lizard density and diversity estimations on the 1-ha grids indicate the low local species diversity in Mongolian deserts (Table 1). The number of species in our grid areas varied from zero to three. Among 45 grids there were two grids with no lizards, 21 grids with only one species, 18 grids with two species and four grids with three species. *Phrynocephalus versicolor* was the only species distributed over the most number of grids (91% of grids occupied). *Eremias przewalskii* was found on 33%, *E. multiocellata* on 24% and *A. papiens* on 4% of grids. Regarding distribution through the main habitat types (Table 1), *P. versicolor* was also the most widely distributed spe-

cies but with the pronounced habitat preference. The second was *E. multiocellata*, and the third was *E. przewalskii*. The last species had the most restricted habitat preference, namely sandy-loess hills in saline depressions with shrub vegetation of *Nitraria* sp.

The abundance of *P. versicolor* was positively correlated with its broad distribution. The density of this species varied from 1 to 106 individuals per 1-ha (Table 1). The second most abundant *E. przewalskii* (44 individuals per 1-ha maximum), and the third was *E. multiocellata* (11 individuals per 1-ha maximum). All three species coexisted at rather high densities in saline depressions with sandy-loess hills covered with *Nitraria* sp. shrubs. There were no pronounced negative correlation between the densities of two dominant species on grids situated within this habitat type (*P. versicolor*-*E. przewalskii*: $R^2=0.04$, $n=20$, ns).

Table 2. Designation and description for the 23 habitat variables included in the analysis.

Mnemonic	Variable	Unit
RCK	Content of rocks in the soil	%%
GRW	Content of gravel in the soil	%%
CLY	Content of clay in the soil	%%
SCS	Sand cover area	%%
SCH	Sand cover height	cm
WDS	Dry river bed area	%%
WDD	Dry river bed depth	cm
NRB	Number of rodent burrows	no/sq.m.
FRB	Abundance of annual forbs	no/sq.m.
AGR	Abundance of annual grasses	no/sq.m.
ANN	Overall abundance of annual grasses and forbs	no/sq.m.
ALL	Perennial <i>Allium</i> cover	%%
PGR	Perennial grass cover	%%
MIC	Cover of microphyllous shrubs	%%
HAL	Cover of halophytous shrubs	%%
SUC	Cover of small succulent shrubs	%%
HLX	Cover of <i>Haloxylon</i>	%%
NIT	Cover of <i>Nitraria</i>	%%
SHC	Overall shrub cover	%%
SV1	Perennial plant crown volume at the level 0-25 cm	%%
SV2	Perennial plant crown volume at the level 25-50 cm	%%
SV3	Perennial plant crown volume at the level 0.5-1 m	%%
SV4	Perennial plant crown volume at the level 1-2 m	%%

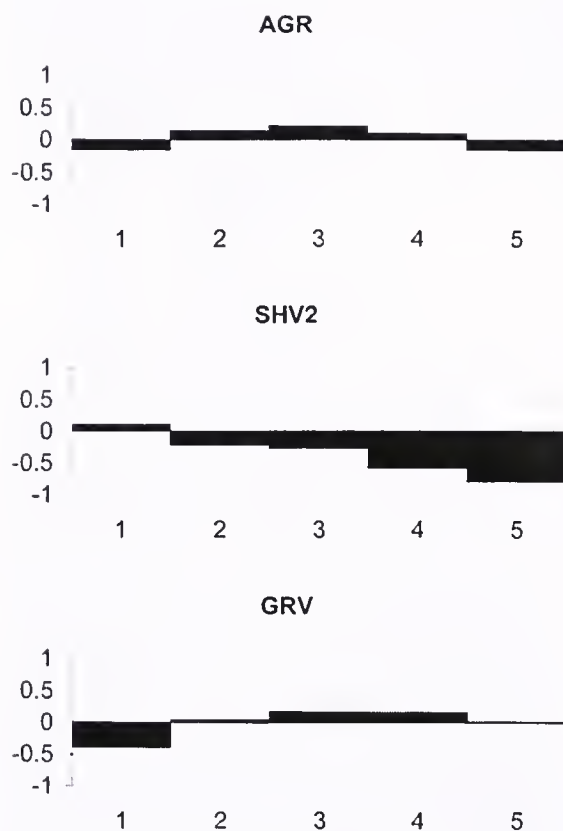


Fig 2. Habitat use profiles of *P. versicolor*. For each habitat variable rank, mean use by species is plotted as a difference between capture frequency on plots of this rank and capture frequency of all plots. The size of histograms therefore denote the selectivity (positive or negative) of habitat use. For mnemonics see Table 2

Spatial niches

There was a statistically significant influence of habitat variables on the distribution and abundance of all three studied lizard species (Table 3). For each of these species we extracted a set of two to three habitat variables, determining 6.6-28.7% of observed variance in abundance. Densities of two species (*P. versicolor*, *E. przewalskii*) were moderately affected by habitat variables, whereas density of *E. multiocellata* was weakly affected.

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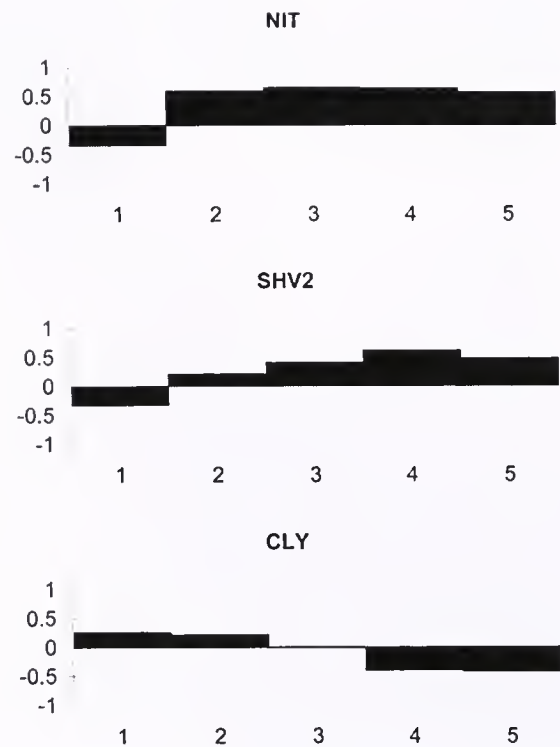


Fig.3. Habitat use profiles of *E. przewalskii*. For explanation see Fig.2.

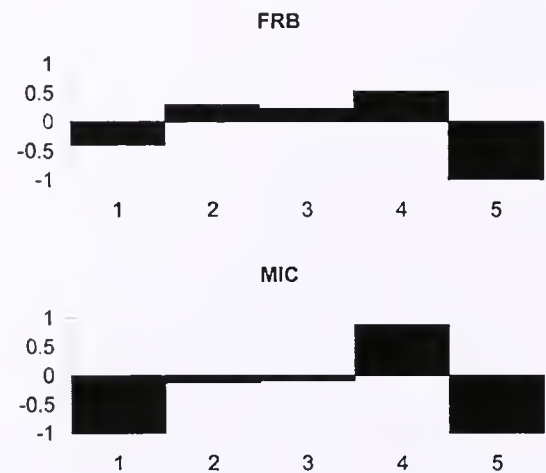


Fig.4. Habitat use profiles of *E. multiocellata*. For explanation see Fig.2.

Patterns of habitat usage based on selected variable sets for each species are presented on Figures 2-4. *Phrynocephalus versicolor* clearly avoided microsites with low gravel content, very low and very high annual grass abundance, moderate and high shrub crown volume in the level 0.25-0.5 m and preferred microsites with moderate gravel content, moderate annual grass abundance and very low shrub

Table 3. Summary of ANOVA analyses of influence of habitat variables on individual species' abundance. Values are proportions of total dispersion determined by given variable. Total proportion of variance determined by a set of variables may be greater than sum of influences of individual variables as a result of high-order interactions.

Species	V a r i a b l e s							Total
	GRV	CLY	AGR	FRB	MIC	NIT	SHV2	
<i>P. versicolor</i>	0.0226		0.0387				0.0458	0.1900
<i>E. przewalskii</i>		0.0593				0.1592	0.0102	0.2872
<i>E. multiocellata</i>				0.0180	0.0232			0.0662

crown volume in the level 0.25-0.5 m (Fig. 2). *Eremias przewalskii* avoided microsites with high and very high clay content, very low *Nitraria* cover, very low shrub crown volume in the level 0.25-0.5 m, and preferred microsites with low clay content, moderate to high *Nitraria* cover, moderate to high shrub crown volume in the level 0.25-0.5 m (Fig. 3). *Eremias multiocellata* avoided microsites with very high and very low forb abundance and microphyllous shrub cover, and preferred microsites with moderate forb abundance and rather high microphyllous shrub cover (Fig. 4).

Structure of ecological space occupied

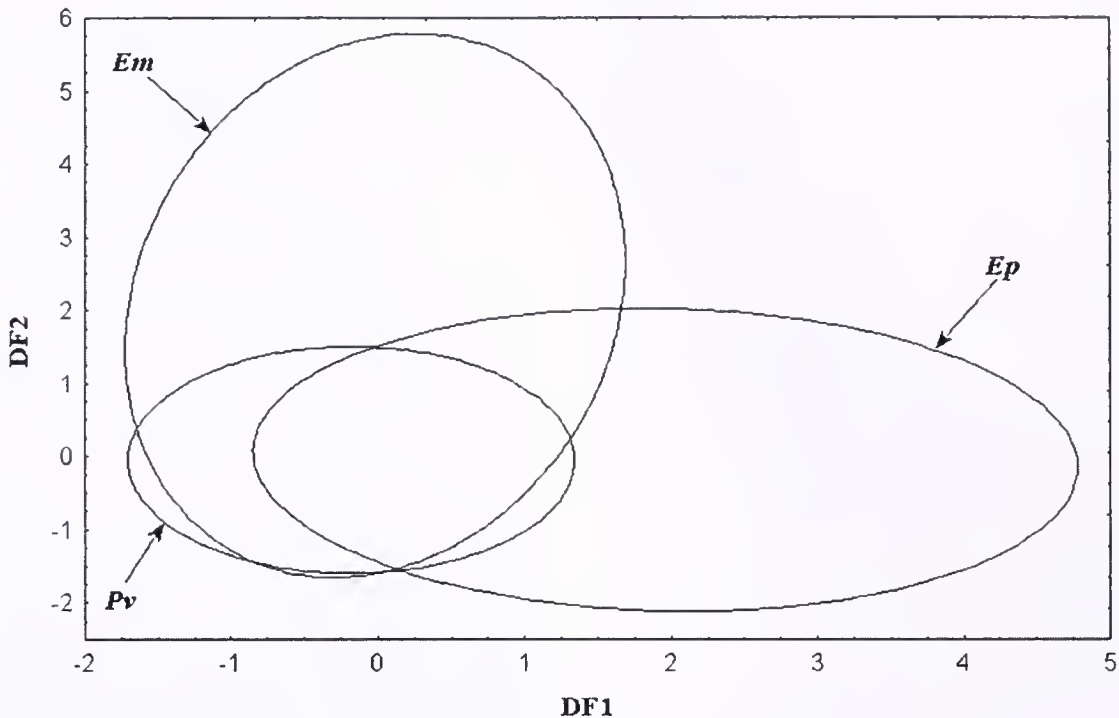
The results of reducing habitat space dimensionality using discriminant analysis showed that division of this space by lizard species occurred along the first two axes. Both axes accounted in sum for 100 % of variance and reflected some complex environmental gradients (Table 4). The first axis represented a general gradient of decreasing rock and gravel content in the soil as well as an increase in the sand cover area, sand mound height, number of rodent burrows and general shrub (especially *Nitraria*) cover. This axis characterized the between-habitat component of environmental variation rather than within-habitat variation, and described in general spatial segregation of lizard species according to their preference of physiognomically distinctive habitats. The second axis reflected an increase of dry river bed area, *Allium* abundance and microphyllous shrub cover, and characterized both between- and within-habitat components of species segregation. The first axis described habitat division between *E. przewalskii* and two other species, whereas the second axis reflected habitat segregation between *E. multiocellata* and two other species (Fig. 5). All three lizard species had spatially remote niche centers and less than 30% niche overlap (Fig. 5).

Discussion

Our data confirm the general opinion of low reptile species richness in Mongolian deserts. There were only four 1-ha grids where three lizard species coexisted. If we take into account rare encounters with snake species, the maximum reptile species number is five. Another opinion about wide spatial niches of Gobiian lizards (Semenov and Borkin, 1986) partly contradicts our results. At the one hand *P. versicolor* is the an abundant species that can be found everywhere in the Gobi desert, including sandy, clay and rocky habitats. This feature of its distribution distinguishes this species greatly from its western congeners that share habitat types in Middle Asia (Shenbrot et al., 1991). At the other hand, *P. versicolor* did have well pronounced spatial preferences as it is seen from Table 1. The two species of *Eremias* lizards had distinctly non-preferable habitats. *Eremias przewalskii* was mainly restricted to one habitat type, and *E. multiocellata* to two habitat types.

Results of analysis of microhabitat preferences demonstrate the existence of significantly distinct environmental variables determining spatial distribution of each lizard species. The variables elucidated can be regarded as axes of species spatial niche. Spatial niches for *P. versicolor* and *E. przewalskii* appeared to be determined by three axes of environmental variation and for *E. multiocellata* by two axes. The distribution of species along each axes can be interpreted in accordance with the biological characteristics of each species. The absence of *P. versicolor* at microsites with dense vegetation is explained by typical *Phrynocephalus* locomotion on straightened legs and by the group-specific visual orientation when foraging (in contrast to *Eremias*, which look for food items using olfaction). *Phrynocephalus versicolor* preferred microsites with moderate gravel content, moderate annual grass abundance and very low shrub crown volume, which characterizes the species as an inhabitant of stony and gravel desert valleys (Fig. 2). *Eremias przewalskii* selected microhabitats in accor-

Fig.5. Seventy-five percent confidence ellipses for the species observations on two discriminant axes (DF1 and DF2). Em-*Eremias multiocellata*, Ep- *Eremias przewalskii*, Pv - *Phrynocephalus vesicolor*.



dance with food abundance and a species-specific tactic of antipredator behavior. It preferred microsites with moderate to high *Nitraria* cover and moderate to high shrub crown volume at 0.25-0.5 m (Fig. 3). In summer *E. przewalskii* feed predominantly on berries and young green twigs of *Nitraria*, and also find protection under the dense cover of the crowns of low spiny shrubs. In contrast to *E. przewalskii*, *E. multiocellata* avoided microsites with very high annual plant abundance and shrub cover, but also preferred microsites with moderate and rather high values of these variables (Fig. 4). This difference can be interpreted in accordance with thermobiological and size characteristics of two *Eremias* species. The larger species, *E. przewalskii* is not so quick as the smaller *E. multiocellata*. The first one digs well in soft soil, and thermoregulates climbing on or escaping under the shrub periodically, being active throughout the day. Small *E. multiocellata* that occupy habitats with relatively low vegetation cover (with small sparsely-distributed shrubs) must cross open sites in search for food items and escape predator's attacks by quickly rushing into small shrubs or burrows. This species reduces heat by escaping into burrow during the day-time.

Another result of the above comparison is the positive relationship between distribution and local abundance among the species considered. Distribution

here means not the size of the species range area, but the number of sites where each species was found. *Phrynocephalus vesicolor* was encountered on 41 grid areas and had the highest population density (mean: 37.3, median: 26 ind/ha, maximum: 106 ind/ha). With the edge-effect correction (Semenov, 1991) maximum density was 70.02 ind/ha (175.5 g/ha biomass). *Eremias przewalskii* was found on 15 grid areas and was the second abundant species (mean: 9.5, median: 4 ind/ha, maximum: 44 ind/ha). *Eremias multiocellata* was found on 11 grid areas and its maximum density was 12 ind/ha (mean: 3.6, median: 2 ind/ha). *Alsophilax pipiens* was met on two grids with density 3 ind/ha.

Brown (1995) explains this rather common relationship by the "Hutchinsonian niche model" (see also for one species, Brown 1984), suggesting that "the species that is slightly more tolerant of some abiotic conditions or biotic interaction or is slightly better able to use some resource should not only be able to occur in more places but also to attain higher abundance in some of those places." In the approach we use here niche breadth reflects microhabitat requirements of each species, namely the range of microconditions where each lizard species occurred. Diversity of these microhabitats is not necessarily correlated with the diversity of macrohabitats as well as with the

Table 4. Summary of discriminant analysis of the habitats of lizard species. DF1 and DF2 are the first two components (all are significant, $P < 0.001$). Mnemonics for habitat variables are from Table 1.

	DF1	DF2
Eigenvalue	0.351	0.102
Chi-square	676.1	165.5
Cumulative % of variance	62.58	37.42
Factor loading		
RCK	-0.350	0.295
GRV	-0.291	0.124
SCS	0.544	-0.221
WDD	-0.091	0.241
NRB	0.442	0.253
SHH	0.627	0.190
ALL	-0.141	0.252
MIC	-0.021	0.410
NIT	0.642	0.193
SHC	0.650	0.148
SV1	0.712	0.067
SV2	0.693	-0.069

size of the landmass studied. *Phrynocephalus versicolor* that was distributed everywhere in the Gobi, and in many different macrohabitats used a rather limited range of microconditions (Fig. 2). In this respect its spatial niche was not broader than the niche of *E. multiocellata*, and was even narrower in comparison with *E. przewalskii*. (Fig. 5). *Eremias przewalskii* which inhabits a rather limited range of macrohabitats is characterized by relatively broad requirements for microconditions along the first discriminant axis which represents the main direction of spatial segregation of lizard species.

The structure of ecological space occupied by three lizard species has a complex character, explaining both macrohabitat and microhabitat segregation of spatial niches. Primarily, each discriminant axis characterizes the range of variation of microconditions in the study area. This can characterize macrohabitats only if variation in a set of variables included into analysis reflects the macrohabitat variation. In our case DF1 and DF2 possess such a feature: DF1 characterizes better the between-habitat component of spatial niche segregation and DF2 characterizes more

the within-habitat component. Three species of lizards share microconditions in two-dimensional ecological space, so that the niche centers appeared to be almost equally distant from the geometrical center of the model (Fig. 5). The two species of *Eremias* lizards share ecological space to a greater extent than each *Eremias* with *P. versicolor*. Niche overlap between species was less than 15%.

It seems difficult to speculate about processes that led to such spatial relationships. Interspecific competition could contribute to spatial segregation of *Eremias* lizards in past, and could determine the low level of niche overlap. The competitive relationship between *E. przewalskii* and *P. versicolor* is unclear. In a pair of neighboring grid areas at one location within one habitat type when one species is in high density, the other one is usually at low density and vice-versa. However, there were no correlation between population densities of these two dominant species when all grid areas within one habitat type were put together. This result is easily explainable because different localities must have different upper limits of species densities according to the local environmental capacities. However, the climatic conditions of Gobi Desert are so unfavored for reptiles (extremely low winter temperatures, great interannual, between- and within-seasonal contrasts in precipitation and temperatures) that it appears unrealistic to assume the space of resources is saturated by individuals, and that populations are at equilibrium.

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The Morphology and Size of Blood Cells of *Lacerta rudis bithynica*

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Abstract.— In this study, the morphology of the blood cells of *Lacerta rudis bithynica* is described using Wright's technique. The sizes of erythrocytes and their nuclei, leukocytes (monocytes, lymphocytes, basophils, neutrophils, and eosinophils), and thrombocytes of *L. rudis bithynica* were measured using an ocular micrometer at a magnification of 1600X with an oil immersion objective. The results of this study are compared with previous work on other reptile species.

Key words.— Lacertidae, *Lacerta rudis bithynica*, erythrocyte, leukocyte, thrombocyte, measurement, morphology.

Introduction

The first studies on the blood of reptiles described the cellular structures, often comparing them with those of other vertebrates. Literature on the haematology of reptilian blood is based on few studies and is usually concerned with European species (Saint Girons, 1970).

Recent studies have concentrated on single species (*Tiliqua* sp., Cannon et al., 1988; *Cyrtopodion scabrum*, Canfield and Shea, 1996). Various authors have described different circulating blood cells of different reptile species (Taylor and Kaplan, 1961; Heady and Rogers, 1962; Hartman and Lessler, 1964; Szarski and Czopek, 1966; Duguy, 1970; Saint Girons, 1970, Cannon et al., 1988, Canfield and Shea, 1996). Other authors have studied seasonal (Hutton, 1960; Cline and Waldman, 1962; Haggag and et. al, 1966) or sexual (Altland and Thompson, 1962) variation in the number of blood cells of different reptile species. In addition, authors have studied the number of blood cells of different reptile species (Charipper and Davis, 1932; Baker and Cline, 1932; Hutton, 1961; Altland and Thompson, 1962; Hutchinson and Szarski, 1965; Engbretson and Hutchinson, 1976). Finally, authors have studied haemoglobin and hematocrit content of blood and hematopoiesis of different reptile species (Altland and Thompson, 1958; Hutton, 1961; Goin and Crawford, 1965; Engbretson and Hutchinson, 1976; Newlin and Ballinger, 1976).

In Turkey, haematological studies have been conducted on humans and economically important animals. However, there are no haematological studies on the Turkish reptiles.

In this study, our aim is to describe and measure blood cells (erythrocyte, leukocyte, thrombocyte) of *Lacerta rudis bithynica* (Squamata: Lacertidae). This study is the first of its kind on a Turkish species.

Material and Methods

In this study, 31 individuals (17 male) of *Lacerta rudis bithynica* (Squamata: Lacertidae) were examined. The study was carried out between June and August 1998. The specimens were collected from Uludağ (Bursa) at an altitude of 1745 m. Blood was obtained by cardiac puncture of the lizards (Canfield and Shea, 1988). Immediately after the blood was obtained in heparinized capillary tubes, the blood smears were prepared. Three to five blood smears were prepared per individual. The smears were air-dried and stored until stained with Wright's stain (Hartman and Lessler, 1964). Twelve drops of Wright's stain were dropped on the slides and allowed to remain on the slide one and a half minutes before rinsing with a phosphate buffer (pH=6.5). The slides were allowed to stand for ten minutes at room temperature and were then washed with distilled water and allowed to dry.

On each slide fifty mature erythrocytes and their nuclei, ten thrombocytes, and ten leukocytes (monocyte, lymphocyte, eosinophil, basophil and neutrophil) were measured by means of an ocular micrometer at a magnification of 1600 x with an oil immersion objective. Cell sizes were calculated from the measurements.

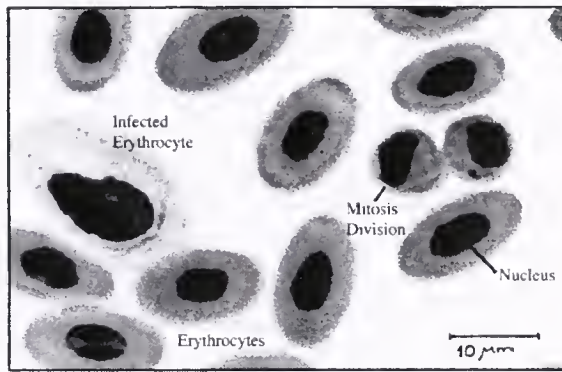


Figure 1. Erythrocytes, an infected erythrocyte and a mitosis division.

Results

I. Erythrocytes

Erythrocytes are nucleated, oval cells. Their nuclei are also oval, more or less regular and centrally located (Fig. 1). The cytoplasm of mature erythrocyte appeared light and dark pink and homogeneous under Wright's stain. The nuclei of mature erythrocytes are chromophilic. In some blood smears, immature erythrocytes are seen. They are characterised by a rounded form, blue cytoplasm and a large nucleus. Mitotic figures are also present and in some smears, intracorpusecular parasites are seen (Fig. 1). Parasites alter the shape and size of erythrocytes remarkably. When intracorpusecular parasites are seen, immature erythrocytes and mitotic figures are abundant (Fig 1). Intracorpusecular parasites alter the shape and size of infected erythrocytes. The shape and size of other erythrocytes that are not infected by intracorpusecular parasites are normal.

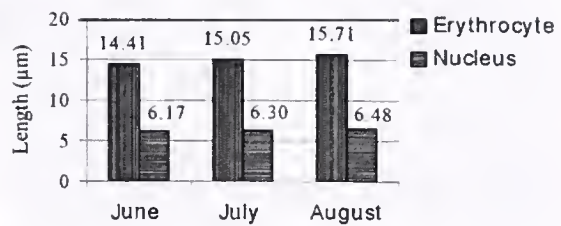


Figure 2. Erythrocyte and nucleus lengths of *Lacerta rudis bithynica* over three months.

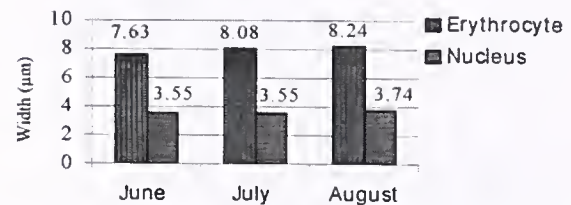


Figure 3. Erythrocyte and nucleus widths of *Lacerta rudis bithynica* over three months.

In June mean length of mature erythrocytes was 14.41 μm (± 0.77 standard deviations, with a range of 12.20–16.47 μm). In July, the mean length of mature erythrocytes was 15.05 μm (± 0.79 , 12.81–17.08 μm). In August, the mean length of mature erythrocytes was 15.71 μm (± 0.79 , 12.81–18.30 μm). Other measurements are given in Tables 1, 2 and 3. There are no significant differences in erythrocyte and nucleus sizes between females and males. Based on Tables 1, 2, and 3 and Figs. 2 and 3, it appears that there were little monthly variations in erythrocyte and nucleus sizes among June, July and August.

II. Leukocytes

1. Eosinophils. In blood smears stained by Wright technique, eosinophils are circular, and the cytoplasm

Table 1. Erythrocyte dimensions of *Lacerta rudis bithynica* with the standard deviations in June. EL: Erythrocyte length; EW: Erythrocyte width; ES: Erythrocyte size; NL: Nucleus length; NW: Nucleus width; NS: Nucleus size.

	EL (μm)	EW (μm)	EL/EW	ES (μm^2)	NS/ES
Maximum	16.47 $\pm$ 0.77	9.15 $\pm$ 0.48	2.27 $\pm$ 0.13	110.41 $\pm$ 8.00	0.30 $\pm$ 0.02
Minimum	12.20 $\pm$ 0.77	6.71 $\pm$ 0.48	1.42 $\pm$ 0.13	64.26 $\pm$ 8.00	0.13 $\pm$ 0.02
Mean	14.41 $\pm$ 0.77	7.63 $\pm$ 0.48	1.89 $\pm$ 0.13	86.46 $\pm$ 8.00	0.20 $\pm$ 0.02
	NL (μm)	NW (μm)	NL/NW	NS (μm^2)	
Maximum	7.32 $\pm$ 0.40	4.88 $\pm$ 0.34	2.20 $\pm$ 0.19	24.53 $\pm$ 2.19	
Minimum	4.88 $\pm$ 0.40	3.05 $\pm$ 0.34	1.25 $\pm$ 0.19	11.68 $\pm$ 2.19	
Mean	6.17 $\pm$ 0.40	3.55 $\pm$ 0.34	1.75 $\pm$ 0.19	17.25 $\pm$ 2.19	

Table 2. Erythrocyte dimensions of *Lacerta rudis bithynica* together with the standard deviations in July. EL: Erythrocyte length; EW: Erythrocyte width; ES: Erythrocyte size; NL: Nucleus length; NW: Nucleus width; NS: Nucleus size.

	EL (μm)	EW (μm)	EL/EW	ES (μm^2)	NS/ES
Maximum	17.08 $\pm$ 0.79	9.15 $\pm$ 0.49	2.16 $\pm$ 0.12	122.68 $\pm$ 8.95	0.28 $\pm$ 0.02
Minimum	12.81 $\pm$ 0.79	6.71 $\pm$ 0.49	1.53 $\pm$ 0.12	67.47 $\pm$ 8.95	0.13 $\pm$ 0.02
Mean	15.05 $\pm$ 0.79	8.08 $\pm$ 0.49	1.86 $\pm$ 0.12	95.62 $\pm$ 8.95	0.18 $\pm$ 0.02
	NL (μm)	NW (μm)	NL/NW	NS (μm^2)	
Maximum	7.30 $\pm$ 0.70	4.27 $\pm$ 0.32	2.40 $\pm$ 0.17	24.53 $\pm$ 2.38	
Minimum	5.40 $\pm$ 0.70	3.05 $\pm$ 0.32	1.33 $\pm$ 0.17	13.14 $\pm$ 2.38	
Mean	6.30 $\pm$ 0.70	3.55 $\pm$ 0.32	1.79 $\pm$ 0.17	17.67 $\pm$ 2.38	

is stained light red. Eosinophils contain circular to elongate cytoplasmic granules stained brilliant red (Fig 4). Eosinophils are different from neutrophils in that, eosinophils' granules are stained bright red and neutrophils' granules were stained dim red.

In June, the mean diameter of eosinophils was 12.82 μm , (± 1.71 standard deviations, with a range of 9.93–15.25 μm). In July, the mean diameter was 13.29 μm (± 1.25 , 10.98–15.25 μm). In August, the mean diameter was 13.80 μm (± 1.37 , 12.20–15.25 μm).

There were no significant differences in eosinophil diameters between females and males. Based on Tables 4, 5, and 6 and Fig. 8, it appears that there was little monthly variation in the diameter of eosinophils during the three months.

2. Basophils. Basophils are easily recognised. They are small and circular cells. Nuclei stained blue by Wright technique are commonly obscured by chromophilic circular granules. These cytoplasmic granules are large and stained dark purple. In the blood

smears, they resemble mulberries (Fig. 5). The granules are so dense that nucleus stained dim blue is rarely seen.

In June, the mean diameter of basophils was 8.55 μm , (± 0.61 standard deviations, with a range of 7.32–9.15 μm). In July, the mean diameter was 9.02 μm (± 0.24 , 8.54–9.15 μm). In August, the mean diameter was 9.00 μm (± 0.45 , 7.93–10.37 μm).

There were no significant differences in basophil diameters between females and males. Based on Tables 4, 5, and 6 and Fig. 8, it appears that there was little monthly variation in the diameter of basophils during the three months.

3. Neutrophils. Neutrophils are circular cells like eosinophils (Fig. 6). These cells are also called as heterophils. They have cytoplasmic granules. The granules are circular and stained dim red. Cytoplasm is stained light red.

In June, the mean diameter of neutrophils was 10.15 μm , (± 1.19 standard deviations, with a range of 9.15–13.42 μm). In July, the mean diameter was 10.49

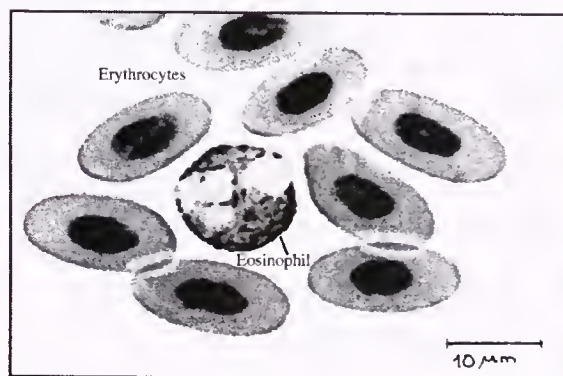


Figure 4. Erythrocytes and an eosinophil.



Figure 5. Erythrocytes and a basophil.

Table 3. Erythrocyte dimensions of *Lacerta rudis bithynica* together with the standard deviations in August. EL: Erythrocyte length; EW: Erythrocyte width; ES: Erythrocyte size; NL: Nucleus length; NW: Nucleus width; NS: Nucleus size.

	EL (μm)	EW (μm)	EL/EW	ES (μm^2)	NS/ES
Max	18.30 $\pm$ 0.76	9.76 $\pm$ 0.48	2.33 $\pm$ 0.12	140.20 $\pm$ 8.96	0.30 $\pm$ 0.02
Min	12.81 $\pm$ 0.76	6.71 $\pm$ 0.48	1.57 $\pm$ 0.12	73.60 $\pm$ 8.96	0.12 $\pm$ 0.02
Mean	15.71 $\pm$ 0.76	8.24 $\pm$ 0.48	1.91 $\pm$ 0.12	101.72 $\pm$ 8.96	0.18 $\pm$ 0.02
	NL (μm)	NW (μm)	NL/NW	NS (μm^2)	
Max	7.93 $\pm$ 0.51	4.27 $\pm$ 0.31	2.40 $\pm$ 0.20	24.53 $\pm$ 2.20	
Min	4.88 $\pm$ 0.51	3.05 $\pm$ 0.31	1.28 $\pm$ 0.20	11.68 $\pm$ 2.20	
Mean	6.48 $\pm$ 0.51	3.74 $\pm$ 0.31	1.74 $\pm$ 0.20	19.05 $\pm$ 2.20	

Table 4. Leukocyte and thrombocyte measurements of *L. rudis bithynica* with the standard deviations in June.

	Lym-phocyte (μm)	Monocyte (μm)	Neutrophil (μm)	Basophil (μm)	Eosinophil (μm)	Thrombo-cyte Length (μm)	Throm-bocyte Width (μm)
Max	8.54 $\pm$ 0.81	12.81 $\pm$ 1.23	13.42 $\pm$ 1.19	9.15 $\pm$ 0.61	15.25 $\pm$ 1.71	7.32 $\pm$ 0.49	4.88 $\pm$ 0.54
Min	4.27 $\pm$ 0.81	9.32 $\pm$ 1.23	9.15 $\pm$ 1.19	7.32 $\pm$ 0.61	9.93 $\pm$ 1.71	4.88 $\pm$ 0.49	3.05 $\pm$ 0.54
Mean	6.12 $\pm$ 0.81	11.10 $\pm$ 1.23	10.15 $\pm$ 1.19	8.55 $\pm$ 0.61	12.82 $\pm$ 1.71	6.12 $\pm$ 0.49	3.72 $\pm$ 0.54

Table 5. Leukocyte and thrombocyte measurements of *L. rudis bithynica* with the standard deviations in July.

	Lym-phocyte (μm)	Monocyte (μm)	Neutrophil (μm)	Basophil (μm)	Eosinophil (μm)	Thrombo-cyte Length (μm)	Throm-bocyte Width (μm)
Max	7.32 $\pm$ 0.41	15.25 $\pm$ 1.50	12.20 $\pm$ 0.97	9.15 $\pm$ 0.24	15.25 $\pm$ 1.25	7.32 $\pm$ 0.52	4.88 $\pm$ 0.42
Min	6.10 $\pm$ 0.41	9.15 $\pm$ 1.50	8.54 $\pm$ 0.97	8.54 $\pm$ 0.24	10.98 $\pm$ 1.25	6.10 $\pm$ 0.52	3.66 $\pm$ 0.42
Mean	6.62 $\pm$ 0.41	11.46 $\pm$ 1.50	10.49 $\pm$ 0.97	9.02 $\pm$ 0.24	13.29 $\pm$ 1.25	6.62 $\pm$ 0.52	4.08 $\pm$ 0.42

Table 6. Leukocyte and thrombocyte measurements of *L. rudis bithynica* with the standard derivations in August.

	Lym- phocyte (μm)	Monocyte (μm)	Neutrophil (μm)	Basophil (μm)	Eosinophil (μm)	Thrombo- cyte Length (μm)	Throm- bocyte Width (μm)
Max	9.15 $\pm$ 0.58	15.25 $\pm$ 1.29	12.20 $\pm$ 0.97	10.37 $\pm$ 0.45	14.03 $\pm$ 1.37	7.32 $\pm$ 0.35	5.49 $\pm$ 0.49
Min	6.10 $\pm$ 0.58	9.15 $\pm$ 1.29	8.54 $\pm$ 0.97	7.93 $\pm$ 0.45	12.20 $\pm$ 1.37	5.49 $\pm$ 0.35	3.05 $\pm$ 0.49
Mean	6.53 $\pm$ 0.58	11.21 $\pm$ 1.29	10.77 $\pm$ 0.97	9.00 $\pm$ 0.45	13.80 $\pm$ 1.37	6.33 $\pm$ 0.35	4.22 $\pm$ 0.49

μm (± 0.97 , 8.54-12.20 μm). In August, the mean diameter was 10.77 μm (± 0.97 , 8.54-12.20 μm).

There were no significant differences in neutrophil diameters between females and males. Based on Tables 4, 5, 6 and Fig. 8, it appears that there was little monthly variation in diameter of neutrophils during the three months.

4. Monocytes. Monocytes are round cells with round nuclei. The cytoplasm is stained blue and the nucleus is stained purple by Wright's technique. The monocyte's cytoplasm is more abundant than lymphocyte's cytoplasm. Nuclei vary in shape (Fig. 7). Nuclei may be nodular, but they are not lobular like granulocytes. Sometimes nuclei are horseshoe-shaped.

In June, the mean diameter of monocytes was 11.10 μm , (± 1.23 standard deviations, with a range of 9.32-12.81 μm). In July, the mean diameter was 11.46 μm (± 1.50 , 9.15-15.25 μm). In August, the mean diameter was 11.21 μm (± 1.29 , 9.15-15.25 μm).

There were no significant differences in monocyte diameters between females and males. Tables 4, 5, 6 and Fig. 8 show that there was little monthly variation in the diameter of monocytes during the three months.

5. Lymphocytes. Lymphocytes are round cells like monocytes, but smaller (Fig. 7). The nuclei contain many parts of the cell. The nucleus is stained purple, cytoplasm, rarely seen, is stained blue.

In June, the mean diameter of lymphocytes was 6.12 μm , (± 0.81 standard deviations, with a range of 4.27-8.54 μm). In July, the mean diameter was 6.62 μm (± 0.41 , 6.10 – 7.32 μm). In August, the mean diameter was 6.53 μm (± 0.58 , 6.10-9.15 μm).

There were no significant differences in lymphocyte diameters between females and males. Based on Tables 4, 5, 6 and Fig. 8, it appears that there was little monthly variation in diameter of lymphocytes during the three months.

III. Thrombocytes

Thrombocytes are small cells like lymphocytes, but they are oval and smaller than lymphocytes (Fig. 9). Their nuclei are highly chromophilic and stained purple. Cytoplasm is rarely seen.

In June, the mean length of thrombocytes was 6.12 μm (± 0.49 standard deviations, with a range of 4.88-7.32 μm). In July, the mean length of thrombocytes

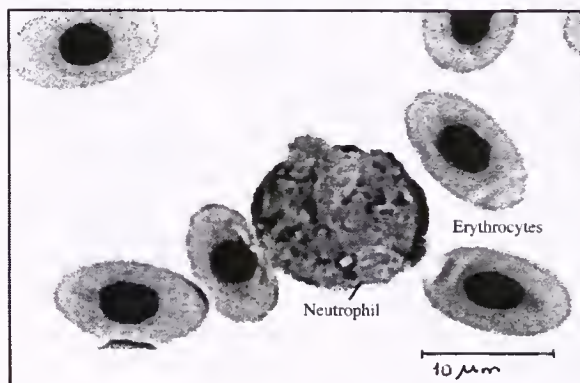


Figure 6. Erythrocytes and a neutrophil.

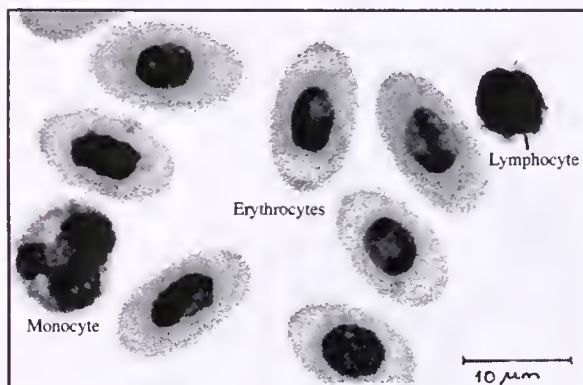


Figure 7. Erythrocytes, a monocyte and a lymphocyte.

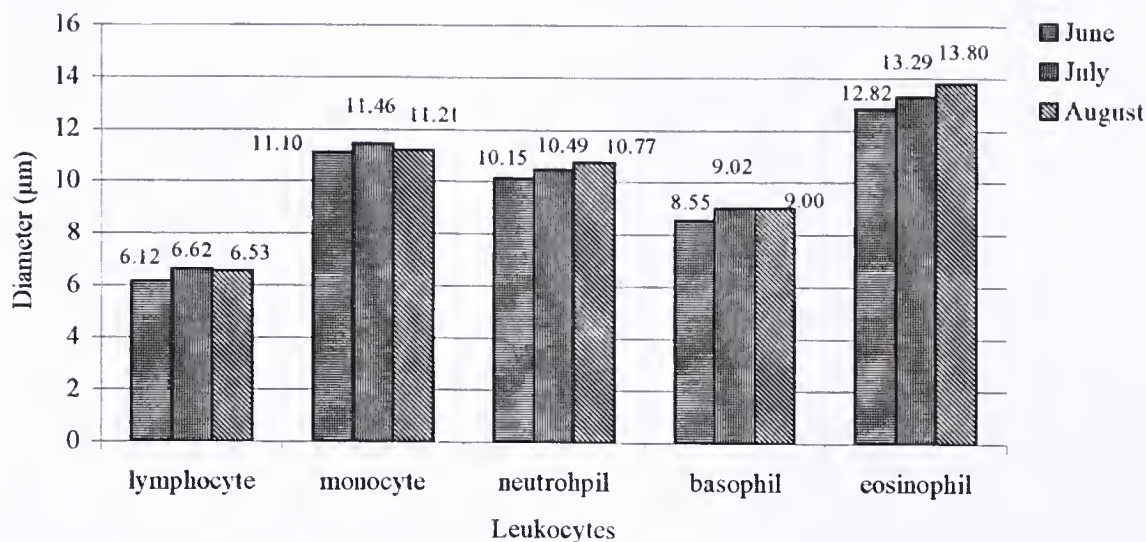


Figure 8. Leukocyte diameters of *Lacerta rudis bithynica* over three months.

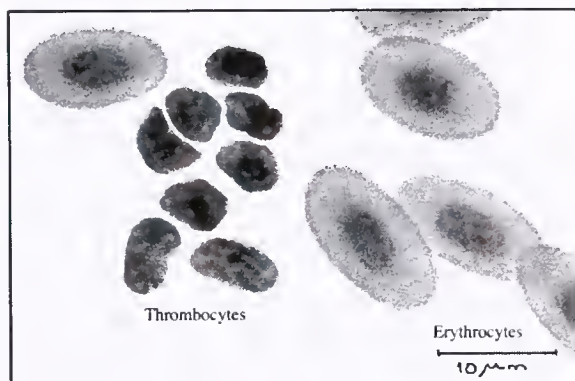


Figure 9. Erythrocytes and thrombocytes.

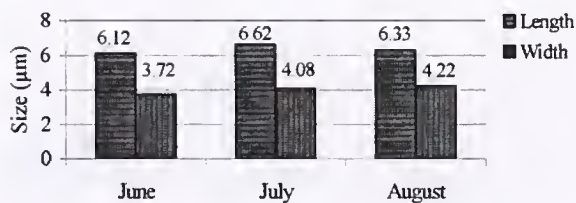


Figure 10. Thrombocyte sizes of *Lacerta rudis bithynica* over three months.

was 6.62 μm (± 0.52 , 6.10-7.32 μm). In August, the mean length of thrombocytes was 6.33 μm (0.35, 5.49-7.32 μm).

In June, the mean width of thrombocytes was 3.72 (± 0.54 standard deviations, with a range of 3.05-4.88

μm). In July, the mean width of thrombocytes was 4.08 μm (± 0.42 , 3.66-4.88 μm). In August, the mean width of thrombocytes was 4.22 μm (0.49, 3.05-5.59 μm).

There were no significant differences in thrombocytes sizes between females and males. Based on Tables 4, 5, 6 and Fig. 10, it appears that there was little monthly variation in thrombocytes sizes during the three months.

Discussion

Investigations carried out by various authors (Hartman and Lessler, 1964; Szarski and Czopek, 1966; Saint Girons, 1970) reported that the sizes of the erythrocytes vary in members of the four orders of reptiles. Within the class Reptilia, the largest erythrocytes are seen in *Sphenodon punctatus*, turtles and crocodilians. The erythrocytes of lizards vary greatly in size depending on the family and sometimes even within one family (Saint Girons, 1970). The smallest erythrocytes are found in the lizard family Lacertidae (Saint Girons, 1970).

In the present study, erythrocyte morphology and the results of erythrocytes sizes (Table 1, 2 and 3) are agreement with the other results carried out by Hartman and Lessler (1964), Szarski and Czopek (1966), and Saint Girons (1970).

In one of the studies on the leukocytes of the rough tail Gecko *Cyrtopodion scabrum*, a bright-field and phase-contrast study Cannon et al. (1996),

reported that the neutrophils were not observed, but the other leukocytes were observed.

Another study on morphological observations on the erythrocytes, leukocytes and thrombocytes of blue tongue lizards by Canfield and Shea (1988) reported that all types of leukocytes were observed.

Saint Girons (1970) and Canfield and Shea (1988) divided granulocytes into neutrophils, basophils and eosinophils on the basis of light microscopy. However Cannon et al. (1996) divided granulocytes into basophils and eosinophils on the basis of bright-field and phase-contrast microscopy.

Heady and Rogers (1962) divided leukocytes into neutrophils, small acidophils, eosinophils, lymphocytes and monocytes on the basis of light microscopy in *Pseudemys elegans*. They, except for monocytes, gave the sizes of leukocytes and reported that eosinophils and neutrophils were numerous than the other leukocytes. Taylor and Kaplan (1961) also divided leukocytes into neutrophils, basophils, eosinophils, lymphocytes and monocytes on the basis of light microscopy in turtles.

In this study, it appears that on the basis of light microscopic findings there are three main types of granulocytes and two types of agranulocytes in *L. rudis bithynica* and also the size of all kinds of leukocytes are given in Table 4, 5 and 6.

In the present study, the descriptions and sizes (Table 4, 5 and 6) of thrombocytes are comparable to other descriptions. Canfields and Shea (1988) reported that thrombocyte morphology at the light microscopic level is influenced by the degree of aggregation and degranulation. Saint Girons (1970) reported that thrombocytes are small, oval cells characterised by elongate, centrally located highly chromophilic nuclei. The cytoplasm is almost colourless (faintly acidophilic) and hence difficult to see in a blood smears. Taylor and Kaplan (1961) reported the same findings in turtles.

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Buccopharyngeal Morphology and Feeding Ecology of *Microhyla ornata* Tadpoles

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Abstract.- The oropharyngeal morphology of *Microhyla ornata* tadpoles is described. Anatomical peculiarities are correlated to feeding ecology. Microhylid anatomical features are discussed and compared with ranoid tadpoles.

Key words.- Amphibia, Salientia, Microhylidae, *Microhyla ornata*, larval oropharyngeal morphology, feeding ecology.

Introduction

The common southeast Asian narrow-mouth frog *Microhyla ornata* is widely distributed throughout Punjab, Sindh, N.W.F.P. and Azad Kashmir (Khan, 1974; 1979; 1988; Khan and Tasnin, 1987). Normally, its small size makes it inconspicuous and difficult to detect in the field. However, after a summer heavy downpour, the characteristic rasping call of *Microhyla ornata* is easily distinguishable from rest of the local amphibians (Khan and Malik, 1987b). *Microhyla ornata* readily takes refuge under vegetation, leaf litter, logs, stones, in holes and fissures in the ground, and often is mistaken as a juvenile of some larger species.

At mid-monsoon, *M. ornata* invades large water bodies, which, by this time, are filled with water and have developed thick planktonic growth. Solitary males perch well away from water among marginal vegetation to call. Eggs are laid in patches of jelly, which float at water surface as "egg-rafts" (Khan, 1982b).

The present study describes oropharyngeal morphology of *Microhyla ornata* tadpole, at Stage 35 and correlate it to the tadpole's feeding ecology. Moreover, it is compared with already known morphologies of sympatric tadpoles belonging to the genera *Bufo* and *Rana* (Khan and Malik, 1987a; Khan and Mufti, 1994b, 1995).

Material and Methods

Tadpoles for the present study were collected during the summers of 1986-88 from different localities along the northwestern border of Rabwah City (Khan and Malik, 1987b). They were netted at midstream with a hand net. *Microhyla ornata* tadpoles from Ghakhar, District Gujranwala, Punjab, Pakistan

(Khan, 1974) and Azad Kashmir (Khan, 1979), were used as comparative material.

Collection, preservation and storage methodology followed Khan (1982b), while surgical procedures and descriptive terminology are from Khan and Malik (1987a) and Khan and Mufti (1994b, 1995), except that for *M. ornata* tadpole, the lateral cuts through buccopharyngeal walls, must pass through mid-eye, unlike ranoid tadpoles where cuts pass below the eye. Fine particulate mucilage-trapped material accumulating in the filter cavities is cleared by a jet of water from an ordinary eyedropper. Drawings of the buccopharyngeal surfaces were made with the help of camera lucida.

Tadpoles at Stage 35 were selected, since at this stage, they have already attained maximum size and their characteristic organs are fully developed and functional. The tadpole at this stage is voraciously feeding and its digestive system is functioning at its full capacity. Shortly after this stage, metamorphic changes start occurring.

For identification of Stage 35, tadpoles were compared with Khan's (1965) table of normal development. Data for present study are recorded from 10 specimens.

Description

External morphology

The tadpole's body is perfectly streamlined; the head is dorsoventrally depressed while its belly is laterally compressed and oval in dorsal profile. The snout is countersunk, displacing mouth anterodorsally. The tail is more than twice the length of the head and body. Broad caudal fins narrow abruptly in the poste-

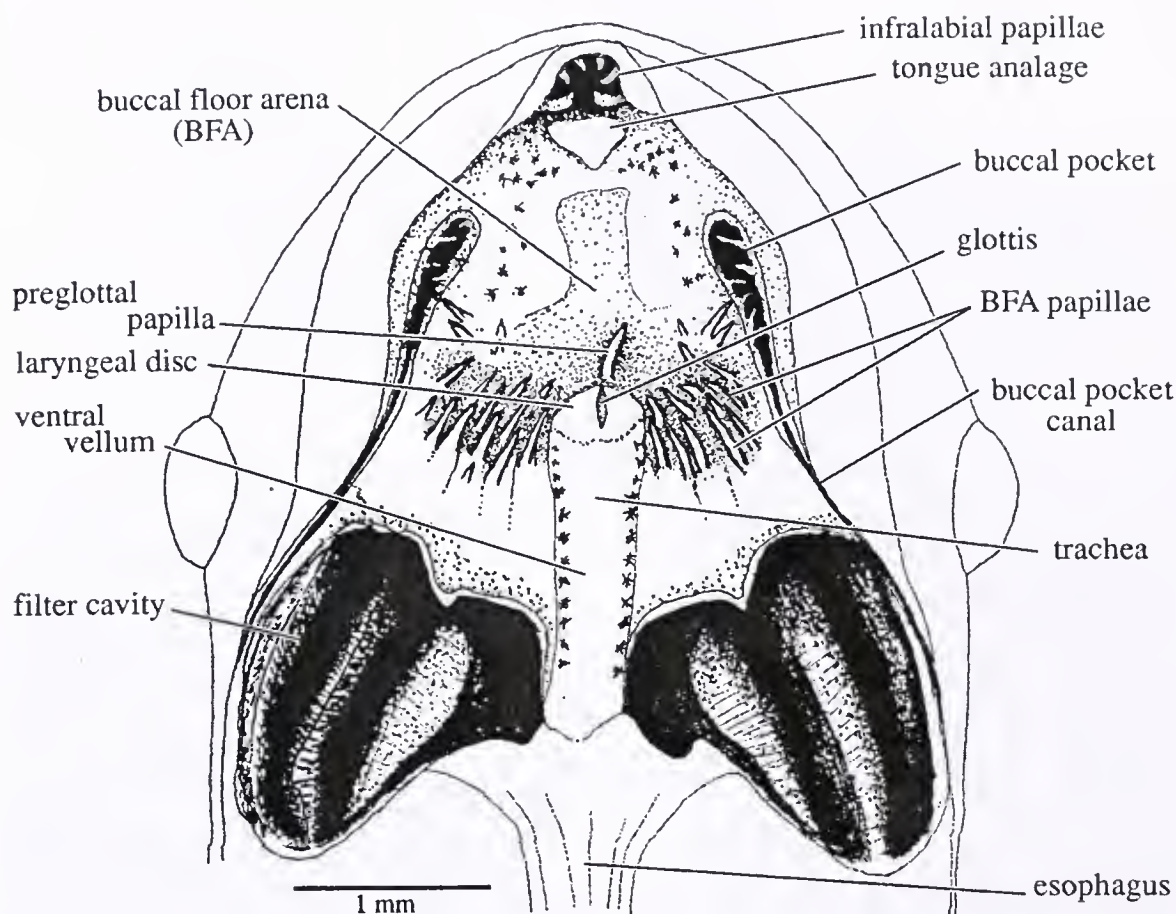


Figure 1. Morphology of surgically exposed buccopharyngeal floor of *Microhyla ornata* tadpole at Stage 35 (scale 1 mm).

rior half of the tail, passing into a delicate long flagellum.

The body is widest at the level of laterally disposed small eyes. The nostrils are imperforate; their position is marked by heavily pigmented anterolateral pits lying just anterior to eyes. The mid-ventral spiracle is close to posterior ventral end of the abdomen, with a distinct prespiracular valve (Khan 1982b).

The horizontal mouth has a median U-shaped cleft in the middle of the lower lip which remains permanently open (Khan and Mufti, 1994a, Fig. 2). Presence of iridiocytes in the abdominal wall, give it a characteristic silvery shine, which is lost within two to three weeks, on preservation. A median dorsal band of melanophores covers the brain and extends onto the base of eyes and the nasal pits.

Measurements (in mm). Body length 5.2-5.8; tail length (including flagellum) 12.6-13.7; total length 17.8-18.9; greatest breadth of body (at the level of eyes) 2.7-2.9; greatest depth of body (at level of spiracle)

3.2-3.4; interorbital space 2.3-2.4; internarial space 0.5-1.95; tail muscle height (at base) 1.7-2.0; tail fin height (at midtail) 4-4.4; length of tail flagellum 2.0-2.3.

Internal Morphology

Buccal region. Khan and Mufti (1994b; 1995) distinguished a tadpole's buccal cavity in two functional units: anterior food gleaning part and posterior food retrieving part. The dorsoventrally depressed head and peculiar position of the mouth in *M. ornata* tadpoles have affected the form and shape of the tadpole's buccal cavity; reducing the food gleaning part and widening the food retrieval part which occupies most of the buccal region.

Ventral buccal (Fig. 1). The floor of the food gleaning part consists of vertical U-shaped prelingual chamber which opens out through mouth at snout top and is lined by a series of three simple infralabial papillae. Posteriorly, it opens in food retrieval part of

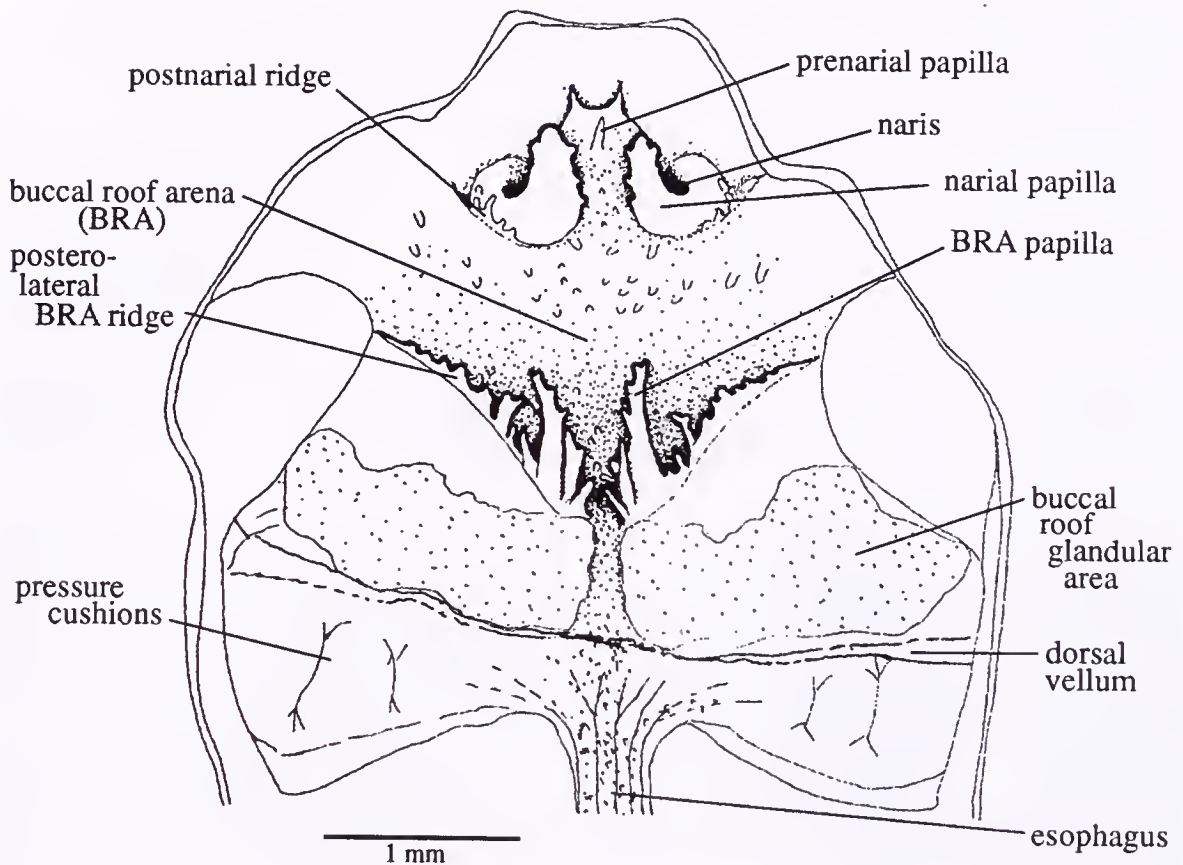


Figure 2. Morphology of surgically exposed buccopharyngeal floor of *Microhyla ornata* tadpole at Stage 35 (scale 1 mm).

the buccal. A non-papillated tongue analage, a conical thickening which is broader anteriorly pointed posteriorly, guards the opening of the food gleaning part into the food retrieval part. The spacious food retrieval part forms the main buccal cavity. The buccal floor arena (BFA) is rectangular, laterally raised with a median shallow passage. A group of 12-14 fine tipped, large, flat BFA papillae lie on lateral sides of anterior end of trachea. A pair of smaller midpocket papillae lie at the level of mid-pockets. A buccal pocket is a long, narrow, club shaped longitudinal slit running anteroposteriorly on each lateral side of the BFA with a posterior narrow canal connecting it with the pressure cushions. Anterior, wider, parts of buccal pockets have 3-6 pre- and 5-8 post pockets, small, conical papillae.

The trachea is a long cylindrical pipe that extends medially to the base of the BFA, carrying the glottis far anterior to the ventral velum and dividing it into lateral halves. The thin lipped glottis is 100% exposed, lies on a bulbous laryngeal disc, and is

guarded by a long preglottal papilla which is tipped left.

The broad ventral velum has a strong spicular support. It covers about 1/2-1/4th of the underlying branchial baskets and consists of three distinct long and deep filter cavities. The free margin of the velum is smooth, with a single broad projection above third filter plate and is covered by a narrow strip of minute secretory pits. Rows of melanophores run along the lateral sides of the buccal arena and are aggregated on the sides of the tongue analage; a row runs along lateral sides of trachea.

Dorsal buccal (Fig. 2). The food gleaning part of the buccal is roofed by a broad prenarial arena, which has a median V-shaped depression with an anterior pre-narial papilla and several pustules. The position of the imperforate naris is marked by a shallow depression from which a flat ribbon like twisted narial papilla hangs down in the buccal cavity. A thin delicate, narrow, papillated, postnarial ridge dorsally delimits narial region and the food gleaning part of the buccal.

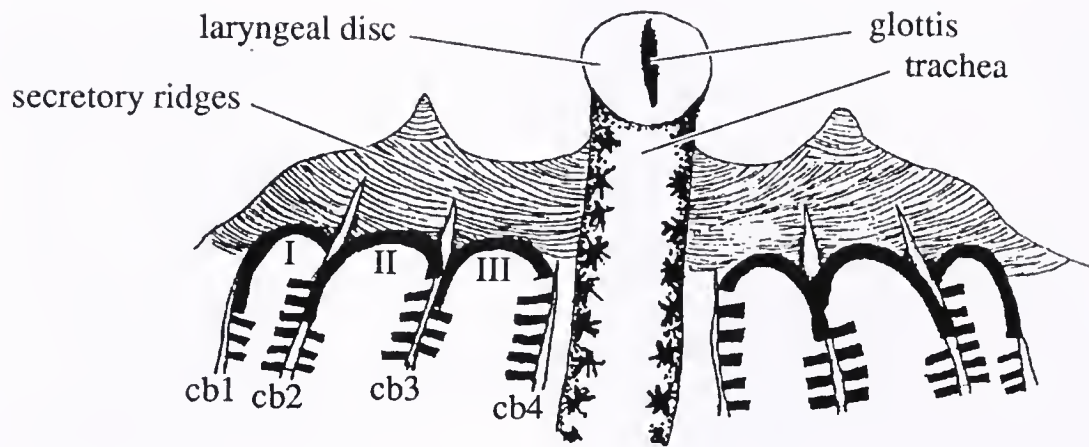


Figure 3. Underside of ventral velum showing details of filter cavities (diagrammatic).

The food retrieval part is roofed by a spacious, broader than long, buccal roof arena (BRA), which is featured mainly by a distinct posterolateral BRA ridge, the free margin of which is cut into flat fine tipped BRA papillae, increasing in length from out smallest, to inside longest, with blunts on their inner sides, while smaller are without blunts. The BRA surface is pustular.

The broad glandular area of the buccal roof is divided into lateral rectangular halves and is covered with dense minute secretory pits. The dorsal velum narrows gradually mesoid, at mid-BRA it staggers to continue with that of other side.

Branchial region. Branchial baskets are more than twice the length of the buccal. Three filter cavities are distinct in each branchial basket. The first filter cavity is largest while the third is smallest. The filter cavities are always packed with filocular matter. The third is tilted outwards, partially blanketing the second. About half to one third of the filter cavities are covered with velum. A distinctly ridged oval torus (Fig.3:I, II, III) is present in each filter cavity. The subvelar surface is profusely ridged with fine transverse secretory ridges

(Fig. 3) that run in line with toric ridges, which are edged with fine secretory pores.

A tight filter ruffle cover the surface of filter plates. The number of filter rows on filter plates vary from minimum 9 on the 4th ceratobranchial to 23 on second (Table 1). The filter ruffle is 3° dense with tertiary foldings. Successive filter rows abut across fully canopied deep filter canals. The filter ruffle covers both sides of second and third filter plates (Fig.3: cb2, cb3).

Three pressure cushions are distinct on posterolateral sides of the dorsal pharynx (Fig. 4). The first and second are four times longer than broad. The first, and outer-most, is continuous anteriorly with the buccal pocket of its side through a buccal pocket canal. Meanwhile, the third, innermost, is broadest and has a median hook-like appendage. Deep ciliary groove runs along posterior border of the pressure cushions towards esophageal orifice along posterior sides of the pressure cushions.

The lungs at Stage 35 are well developed, each running along the dorsolateral sides of the abdominal cavity, extending to the posterior end of the abdomen. Anterior half of the lung is broad, with well-devel-

Table 1. Branchial elements of *Microhyla ornata* tadpoles at Stage 35 (Ant=anterior aspect; B=breath; cb=ceratobranchial; L=length; Post=posterior aspect). Data from 10 specimens, all measurements in mm.

Ceratobranchial	Filter plate		Filter rows/side	
	L	B	Anterior	Posterior
cb. 1	3.5	1.8	0	15-18
cb. 2	3.7	1.5	13-16	20-23
cb. 3	2.5	1.4	16-17	13
cb. 4	1.9	1.2	8-9	0

Table 2. Comparison of microhylid and ranoid tadpole.

Character	Microhylid	Ranoid
Head	depressed	depressed
Belly	compressed	depressed
Color	transparent	Drab + pattern
Tail length	2-3 times body	2-2.5 times
Tail muscle	narrow	broad
Tail fins	broad	moderate
Tail tip	produced in a flagellum	round/pointed
Spiracle	median ventral	dextral
Belly wall	silver-shiny	transparent or drab
Mouth	antero-dorsal	anterior/antero-ventral
Oral disc	absent	present
Nostrils	imperforate	perforate
Narial flap/papillae	flap	papillae
Infralabial papillae	simple	palmate
Lingual papillae	absent	present
Postnarial papillae	small on a membrane	long solitary
Lateral ridge papilla	absent	present
Median ridge	absent	present
Buccal musculature	poor	well developed
Branchial basket	longer than broad	broader than long
Pharyngeal/buccal ratio	75 %	45-50 %
Prenarial ridge	absent	pustules or ridge
BRA/BFA papillae	flat fine tipped	short forked blunted
BRA/BFA papillae	form membranes	distinct no membranes
Glottis	100% exposed	not or partial exposed
Glottal disc	bulbous	concealed
Glottal position	anterior to vellum	posterior to vellum
Glottal papilla	present	absent
Trachea	long	absent
Secretory tissue	single celled	multicellular
Subvelar secretory tissue	ridged	ridged/pitted
Filter cavities	3	2/3
Maximum filter rows	15-23	10-14
Position of tori	all filter cavities	absent or first cavity
Filter cavity depth	as long as deep	longer than deep

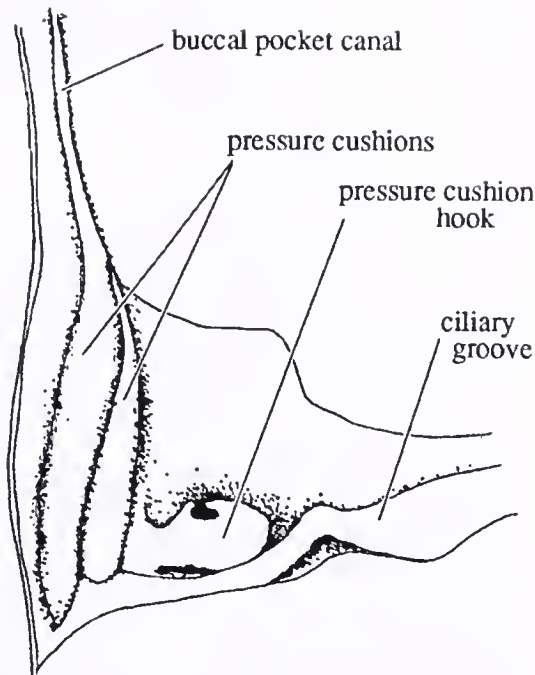


Figure 4. Morphology of posterolateral part of dorsal buccopharyngeal region, showing details.

oped air sacs, it gradually narrows down caudally and its terminal part is a dark pigmented cord.

Ecological Correlates

The adult *Microhyla ornata* is sharply contrasted from its sympatric ranoids in its choice of breeding site and mode of egg deposition. Usually its breeding sites are deep ponds, which develop rich planktonic bloom during summer. Such sites are quite restricted and rare in temperate Punjab, unlike sympatric ranoids who breed in temporal sites that dry in the summer. Intermittent unpredictable rains or irrigation seepage saves such populations of tadpoles (Khan and Malik, 1987b).

Table 1 and 2 summarize peculiar features of *M. ornata* tadpole necessary to suit its lentic habits: perfectly streamlined transparent body and long broad finned tail with independently vibratile terminal flagellum, lateral eyes, median ventral spiracle, abdominal silver-shine, are adaptations to nektic habits of the *M. ornata* tadpole. A school of tadpoles swimming at midstream is almost invisible from above the water due to tadpole's transparent bodies. Meanwhile abdominal coloration makes them invisible in water since the water surface viewed from inside appears shiny due to reflection of light from water. A vibrating

tail flagellum and the jet of water from median ventral spiracle supports the microhylid tadpole at mid-stream, while its buoyancy is maintained by dorsally placed air filled lungs. A long broad finned tail helps the tadpole to react quickly to any stimulus including enemies and food in the water column above and below.

Microphagous tadpoles are characterized by an exaggerated oropharyngeal region (Wassersug, 1980). All oropharyngeal modifications distinguishing microhylid tadpoles from bufonids and ranids are adaptations to microphagy: reduction of infralabial cartilage, corresponding reduction in prelingual and prenarial arenas; displacement of mouth to snout top; simple infralabial papillae; absence of lingual papillae; membranous postnarial and BRA papillary ridges; divided fine pitted buccal glandular zone; fine ridged subvelar and toric glandular surfaces; broad medially divided spiculary supported ventral velum; compact thick filter ruffle on broad and deep filter plates; deep filter cavities with distinct tori. These microhylid structures are part of obligate microphagus filter feeding technology. Similarly long tubular trachea, bulbous laryngeal cartilage, distinct anteriorly displaced glottis with a preglottal papilla, and dorsal, long, air filled lungs are not only efficient parts of an efficient pulmonary aeration system, but at the same time, serve to maintain hydrostatic balance of the tadpole at mid-stream position. The complex morphology of pressure cushions and their connection with buccal pockets are a part of a system which maintains a sustained drainage of excessive buccal water in pressure cushions, providing necessary turgidity during each stroke of bucco-pharyngeal pumping. Turgid cushions act as pharyngeal valves in the process and play key role in sustained pumping of food-laden water current in buccopharyngeal passage.

Morphologically, the *Microhyla ornata* tadpole is a perfect model suited for sustained midstream swimming. It has all the necessary oropharyngeal technology to filter and feed on the planktonic bloom in deeper ponds in temperate Punjab.

Microhylid Tadpole Characters

The microhylid tadpole is ranked as Type 2 in Orton's (1953) classification. It markedly differs in morphologically from ranoid Type 4 macrophagus tadpole (Table 2). Microhylid is the only tadpole, in Punjab riparian ecosystem, occupying unique midstream feeding niche, while rest of the sympatric ranoid tadpoles are bottom grazers and in no way compete with microhylid tadpole. Distinguishing morphological characteristics of *Microhyla ornata* tadpoles are:

External morphology

1. Transparent body and tail, silver-shine on abdomen.
2. Head dorso-ventrally depressed, body and tail laterally compressed.
3. Antero-dorsal mouth, without keratinized oral disc and other associated organs.
4. Eyes prominent, laterally disposed on head.
5. Tail broad finned, its tip produced into a terminal vibratile flagellum.
6. Spiracle median-ventral, mid-abdominal, squarish opening, with a prespiracular flap.
7. Anal tube straight, median-ventral anal opening.
8. Schools of tadpoles swim at midstream schools, never rest at bottom. Capable of making spontaneous movements from midstream to darker parts of the pond to avoid intruders, shortly reappearing at the same midstream site.

Internal morphology

9. Opercular chamber extending to vent.
10. Smooth broad ventral vellum, divided into right and left halves.
11. Long pipe like trachea carries, bulbous glottal cartilage, for forward in buccal cavity. Glottis thin lipped, 100% exposed.
12. Preglottal papillae guarding glottis.
13. No lingual papillae.
14. No lateral ridge papilla and median ridge.
15. Pharyngeal region exaggerated, about 75 % of oropharyngeal region, branchial baskets large with distinct, deep filter cavi ties, which are usually full of floccular matter in dissected tadpoles.
16. Tight filter mesh, maximum number of filter rows 13-23 on either sides of the ceratobranchials.
17. Branchial food traps with microscopic openings of secretory glandular tissue borne on fine parallel ridges forming distinct crescentric torus in each branchial cavity.
18. Imperforate nares with a foliaceous broad narial palp, descending into the buccal cavity.
19. Ceratohyal with a ventrally directed lateral arm, and an antero-posterior median arm.
20. Broad based BRA and BFA papillae, which usually coalesced to form fine membranes.
21. Narrow lateral buccal pockets with distinct connection with pressure cushions, forming an elaborate system to control function of pressure cushions.

Microhylids are phylogenatically connected with ranoids through tadpoles with intermediate morphologies like *Pseudohemius granulosa* (Wassersug, 1984) and *Otophryne robusta* (Wassersug and Pyburn, 1987).

Discussion

Independent vibratile distal caudal flagella are characteristic of mid-stream swimming microphagus tadpoles (Wassersug, 1980, 1989; Wassersug and Sperry, 1977; Nishikawa and Wassersug, 1988, 1989; Hoff and Wassersug, 1986). Maintenance of midstream position is made possible by independent movements of the caudal flagellum and ventrally directed continuous water from the spiracle giving a sustained upward thrust (Khan, 1982a, 1991). Apart from morphological differences in structure of notochord and arrangement of caudal nerves, microhylids and ranoids differ in the site of generation of propulsive locomotory waves. In ranoids, waves are generated at the tail; the tip acts as a steer. In microhylids, waves are generated at the end of the caudal flagellum.

The limited tail musculature and bulky form of the amphibian tadpole restricts its movements so that it cannot evade its potential enemies, fishes, niads, etc., (Khan and Mufti, 1994b; 1995). Amphibian tadpoles rely on a reduced conspicuousness. Its drab spotted pattern blends well against natural aquatic background with moderate to thick vegetation (Caldwell, et al., 1981; Gatten et al., 1984; Kehr and Basso, 1990; Khan and Mufti, 1994 b, 1995). The microhylid tadpole, which is exposed at midstream, solves this problem differently. Transparency of its body reduces its shadow at pond bottom and its abdominal shine blends well against water surface reflecting sun rays, making it invisible from inside pond as well from outside, to its predators.

Microhyla ornata has a larger buccal volume than ranoids. It constantly pumps large amounts of water to get food (Seale and Wassersug, 1979; Wassersug, 1980). Due to its specialized feeding habits, several elements universally present in ranoid tadpoles are missing in its oropharyngeal morphology: median ridge, lateral ridge papillae and lingual papillae. Moreover, papillae in the food retrieval part are a part of particulate food guiding membrane rather particulate food retrieving sieves. Moreover, microhylids have fine-ridged oral and branchial glandular system with fine pits, a specialization to entrap finest particulate food. Deep filter cavities, long filter plates and tight filter mesh are more a part of food retrieval system rather respiratory in function (Wassersug and Murphy, 1987). Particulate food filtering capacity of

filtering system is enhanced by development of a fine-ridged torus in each filter cavity. A well-developed pulmonary system with long tubular trachea, a totally exposed guarded glottism, and inflated dorsal functional lungs are adaptations to the midstream sustained swimming and are efficient respiratory organs (Khan, 1991).

Tadpoles of the microhylid genera *Otophryne* and *Pseudohemismus* show both ranoid as well as microhylid characteristics. Frogs of Family Microhylidae and Ranidae have distinctive adult morphology, however definition of microhylid larva stands only on imperforate naris, since the ranoids have always perforated naris (Wassersug, 1989).

Tadpoles of *M. ornata* from Pakistan differ in morphological details from those collected from Thailand by Inger (1985) in having longer infralabial papillae, more filter rows, presence of postnarial membranous ridge, BRA and BFA membranous papillae, mesially divided dorsal buccal glandular zone, and a single preglottal papilla. Moreover, no silver shine is reported on the belly of tadpoles from Thailand, as is reported from India (Rao, 1917; Azad Kashmir (Khan, 1979) and District Jhang, Punjab Pakistan (Khan 1982a). Flower (1899) reported morphological differences among adults and larvae of this species from Malay peninsula and Siam, while Liu (1950) has reported dextral anal tube in tadpoles from China, which is straight in Pakistani tadpoles. These morphological differences may refer to geographical races within this widely distributed southeast Asian species of narrow-mouth frogs.

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Variation in *Pelobates syriacus* of Turkey

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Abstract.— Morphometric data and color patterns of *Pelobates syriacus* from different regions of Turkey were compared. *Pelobates syriacus* from Edirne appear to be distinct in terms of color pattern. *Pelobates syriacus* from Seydişehir appear to be distinct in terms of morphometric measurements.

Key words.— *Pelobates syriacus*, Turkey, morphometry, color pattern

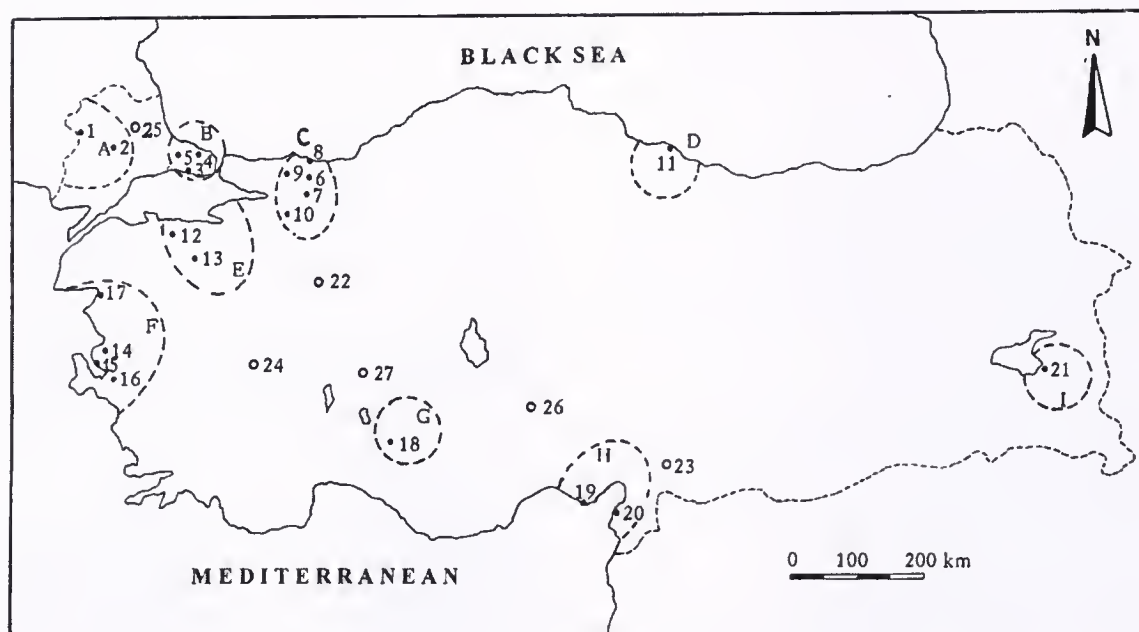


Figure 1. The places where *Pelobates syriacus* have been collected in Turkey. The key to the letters is found in Table 2. Dark circles = The localities where we collected specimens. Open circles = The localities where specimens were collected before. 1. Büyükdöllük, 2. Babaeski, 3. Altınşehir, 4. Terkos, 5. Yassiören, 6. Adapazarı, 7. Söğütlü, 8. Karasu, 9. Poyrazlı Lake, 10. Çerkeşli, 11. Terme, 12. Karacabey, 13. Bursa, 14. Şakran, 15. Bostanlı, 16. Bornova, 17. İvrindi, 18. Seydişehir, 19. Karataş, 20. İskenderun, 21. Van.

Pelobates syriacus Boettger 1889 was first described from specimens collected from Hayfa-Israel. Later, Mertens (1923) examined two specimens, found in Belesuwar near the Azerbaijan and Iran border. Because of their long and narrow skull and the round and raised frontoparietals, he recognised them as another subspecies, *Pelobates syriacus boettgeri*.

Other specimens from Macedonia were described by Karaman (1928) as the subspecies *Pelobates syriacus balcanicus*. Müller (1932) criticized this classification based on the shape of the skull. He emphasised that skull shape can be variable. Another subspecies

living around Tiflis, Georgia was named *Pelobates syriacus transcaucasicus* by Delwig (1927). According to Gilson (1937), this subspecies is intermediate in morphology between *P. s. boettgeri* and *P. s. syriacus*, and Terentjev and Chernov (1965) are convinced that *P. s. transcaucasicus* is a synonym of the nominate race. Furthermore, Eiselt and Schmidtler (1973) proposed *P. s. boettgeri* as a synonym for *P. s. syriacus*.

The taxonomic status of Turkish *Pelobates syriacus* is poorly studied. Mertens (1953) described a young sample collected in Van (Turkey) and suggested that it was *P. s. boettgeri*. Zaloğlu (1964) stud-

Table 1. Percentage of each color pattern in populations of *Pelobates syriacus*.

Population	A	B	C	D
Edirne	-	-	100	-
Istanbul	56.66	40.00	3.34	-
Adapazari	11.54	11.54	11.54	65.38
Samsun	68.42	21.05	-	10.53
Bursa	73.92	21.73	-	4.35
Balikesir-İzmir	15.00	75.00	5.00	5.00
Seydişehir	7.70	-	-	92.30
Adana-İskenderun	66.00	-	-	34.00
Van	14.38	14.28	-	71.44

ied *Pelobates syriacus* from the Turkish region of İzmir. He made an osteological comparison of characters used to differentiate the subspecies of *P. syriacus*. He pointed out that these characters showed a wide range of variation, and refrained from classifying the İzmir *P. syriacus* into subspecies.

In this study, samples (77 male, 57 female, 25 juveniles, 35 larvae) collected from 9 different areas (Istanbul, Adapazari, Samsun, Bursa, İzmir-Balikesir, Seydişehir, Adana, Van) were investigated to obtain more information about variation in *Pelobates syriacus* living in Turkey (Fig. 1).

Results and Discussion

There are four kinds of dorsal patterns on *Pelobates syriacus* (Fig. 2). The dorsal patterns are not sexually dimorphic. The percentage of dorsal patterns are follows: A: 36.08 %, B: 25.95 %, C: 13.92 %, D: 24.05 %. When all the samples are compared, it is seen that the dorsal pattern of Edirne population is different than the other populations (Table 1).

All of the adults from Edirne have big green dots narrow raised surrounding on the back. The background color of the back is light yellow-green. On this background there are connected raised surrounding with brown-green dots. Those dots also appear on all extremities. Furthermore, on the background color, and within the brown-green dots, are yellow and red dots. These dots are missing on the upper side of the front fingers. Dots on the body become smaller on the side. All the Edirne population have C pattern type (Fig. 2).

In terms of morphological measurements, *Pelobates syriacus* populations living in Turkey are very similar. Here, the exception is the Seydişehir population which have shorter indices of tibia length (Table 2).

The differences in the color patterns of adult animals from the Edirne population and the morphomet-

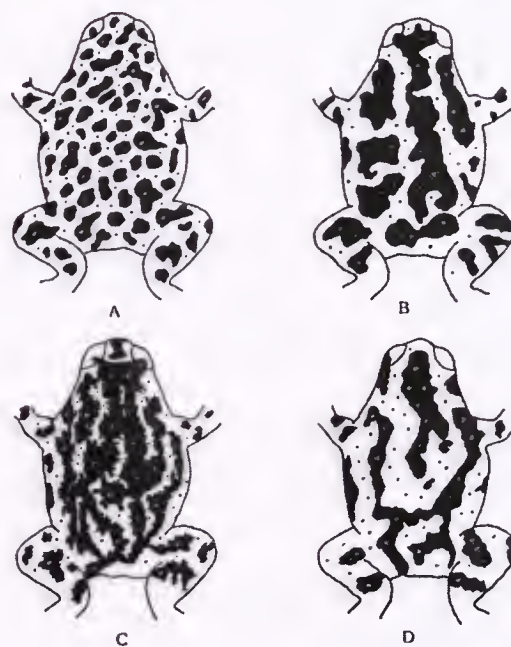


Figure 2. Types of color patterns in *Pelobates syriacus*. A: Spots are irregularly distributed and isolated. B: Two or more spots combine to form irregular islets. C: The edges of the spots are wavy and connected by thin bands. D: Spots form lengthwise bands.

ric differences of the Seydişehir population should be explored using biochemical data in order to determine whether the *Pelobates syriacus* from these regions represent different taxa.

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Translation: A New Species of the Turtle Genus *Cuora* (Testudoformes: Testudinidae)

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Original English Abstract.- *Cuora pani*, sp. nov. (Figs. 1, 2). Holotype, SIZ 80170, an adult male. Allotype, SIZ 80171, an adult female. All of these type specimens were collected from Xujiaba (alt. 420 m) of Pingli County in Shaanxi Province, on June 17, 1981 by the author, and are preserved in the Shaanxi Institute of Zoology. This new species is similar to *Cuora yunnanensis* (Boulenger), but differs from the latter in having the median keel not conspicuous and no lateral keels; a brown narrow band extending from behind eye to the neck; the suture between gulars 1.5 times as long as that between humerals and much shorter than those between pectorals and between anals, but longer than that between femorals; the plastron yellow, with black sutures; and the limbs brown, without any markings.

Song, M. T. 1984. A New Species Of The Turtle Genus *Cuora* (Testudoformes: Testudinidae). *Acta Zootaxonomica Sinica* 9(3):330-332. (In Chinese with English abstract)

There are six species belonging to the genus *Cuora* Gray, 1855 (Pritchard, 1967; Sichuan Institute of Biology, 1977), that are distributed in Thailand, Cambodia, Malaysia, Indonesia, the Philippines, and southern provinces of China.

In 1981, two *Cuora* specimens were found during a survey of Mt. Dabashan, Shaanxi Province. These specimens are different from the six known species and are recognized as a new form. Its description is given below.

Cuora pani, sp. nov. (figs. 1-2)

The holotype, SIZ 80170, is an adult male. The allotype, SIZ 80171, is an adult female. Both of the type specimens were collected from Xujiaba (alt. 420 m) of Pingli County in Shaanxi Province, on June 17, 1981 by the author, and are preserved in the Shaanxi Institute of Zoology.

Diagnosis

The new species is similar to *Cuora yunnanensis* (Boulenger), but differs from that species by having a median keel that is not conspicuous and no lateral keels; a brown narrow band extending from behind the eye to the neck; the seam between the gulars 1.5 times as long as the seam between the humerals and much shorter than those between pectorals and between anals, but longer than that between femorals; the plastron yellow, with black markings along the seams; the limbs are brown and without any markings.

Description of Holotype

The carapace is flattened, with an inconspicuous median keel. The cervical scute is small. The anterior margin of the first vertebral is flaring, the anterior margin wider than the posterior margin. The second vertebral is square-shaped, with both sides are slightly protruding. The third and the fourth vertebrae are as wide as long, with the fourth vertebral being wider than long. The first pleural is the longest, the second is wider and as long as the third, and the fourth the smallest. There are twelve marginals. The first marginal is the widest, the third to seventh and the ninth to tenth are slightly flared.

The plastron is rounded anteriorly and notched posteriorly. The plastron can completely close the shell and is united to the carapace by ligamentous tissue. The ligamentous tissue is also between the pectorals and abdominals. The length of gular seam is 1.5 times the humeral seam, and much shorter than pectoral, abdominal, or anal seam. The pectoral seam is as long as abdominal seam, the anal seam a little shorter, and the abdominal seam is nearly twice the length of the gular seam; femoral seam much shorter, only a little longer than humeral seam. There are a pair of anals that are notched posteriorly.

The head is moderate in size, smooth on top, and rather rough in the occipital region. The snout is pointed, projecting over the upper jaw. The diameter of the orbit is about the same of the length of snout. Upper jaw is slightly curved and a little longer than the lower jaw.



Figure 1. The holotype (SIZ 80170), an adult male, in dorsal view.

The forelimb is covered by imbricate scales posteriorly and with a transverse series of large scales on ventrally. The hindlimb is covered by scales medially and on the tarsus. There are five claws on the forelimb and four on the hindlimb. The webbing between the digits is well developed. The tail is short, conical in shape. The tail is covered by granular scales on its back, and covered with paired scales forming a longitudinal groove ventrally.



Figure 2. The allotype (SIZ 80170), an adult female, in ventral view.

Color in life

The carapace is light brown. The plastron and ventral side of marginals are yellow, with broad black bars along the seams. The top of the head is olive, dark gray laterally, with two brown stripes behind the orbit and along tympanum to neck. The tympanum is light gray. The lower jaw and chin are grayish-yellow. The back of the neck is brown, but lighter ventrally. The shoulders are light yellow and the axilla are yellow. The limbs and tail are light brown above and gray below. The pelvic region and the area behind the fem-

ora are light yellow. The claws are brown with their tips yellow.

Allotype

The seams of the plastron are not as black as in the holotype, the back of tail is covered with a few large scales.

Acknowledgments

This translation was provided by Ermi Zhao with permission of Acta Zootaxonomica Sinica. The figures were provided by Ming-Tao Song.

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Table 1. Measurements of types (in mm).

Specimen	Sex	Head length	Head width	Head height	Tail length	Carapace length	Carapace width	Shell height	Shell height/ Carapace length (%)
Holotype	Male	32	18	16	18	120	86	40	33.3
Allotype	Female	33	18	18	27	115	81	37	32.2

Translation: *Testudo graeca anamurensis* ssp. nov. from Asia Minor

HEINZ WEISSINGER

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Weissinger, H. 1987. *Testudo graeca anamurensis* ssp. nov. aus Kleinasien. ÖGH-Nachrichten (Wien) 10/11: 14-18

The South-western coast of Turkey, from the Bey mountains near Antalya eastwards up to Mersin is the area of distribution of a *Testudo graeca* which is characterized by an elongated, trapezium-shaped and strongly flattened carapace. This southcoast-population was so conspicuous among the more than 200 specimens which I examined and measured in Turkey, that I consider them a geographic subspecies and describe them as follows:

Testudo graeca anamurensis nov. ssp.

Material

Type: One female, Anamurum; NMW 30795:1

Paratypes: One male, Anamurum; NMW 30795:2df

One female, Side; NMW 30795:3

Both alive in the author's collection

Terra typica

Beach of Anamurum, 7 km. west of Anamur, SW coast of Turkey.

Diagnosis

Differs from *Testudo graeca ibera* Pallas 1814 by its considerably flatter and narrower (elongated trapezium-shaped) carapace. The length of the carapace is two-and-a-half times its height and one-and-a-half times its width. In most cases the carapace pattern is a completely broken, obvious blotchy pattern. The plastron has a sharply demarcated pattern of brown to black blotches, which can cover the plastral area for 20 - 100 %. In 80 % of cases, 100% at the terra typica, the animals have a white-yellow chin and throat. The head can be uniformly dark to irregularly spotted with yellow. A triangle on the snout - as in *Testudo graeca terrestris* Forskal 1775 - may be present only in early juvenile stages. In the subspecies most abundant in Asia Minor, *Testudo graeca ibera* Pallas 1814, the carapace is oval, domed regularly and has a smooth posterior margin. Its ground colour is bright olive with large yet individual blotches. The head and extremities are most often uniformly dark. The plastron usually shows indistinctly bordered blotches.



Figures 1-3. (Top and bottom left) *Testudo graeca anamurensis* ssp. nov.; paratype. female NMW 30795:3.

Figure 4. (Bottom right) *Testudo graeca* Ssp. *anamurensis*, male. Anamurum (left); ssp. *ibera*, female, Köyegiz (right).

Table 1. Measurements (straight-line distance) of the type specimen and a paratype

	NMW 30795:1	NMW 30795:3
Carapace length	260 mm	210 mm
Carapace width	160 mm	135 mm
Carapace height	105 mm	88 mm

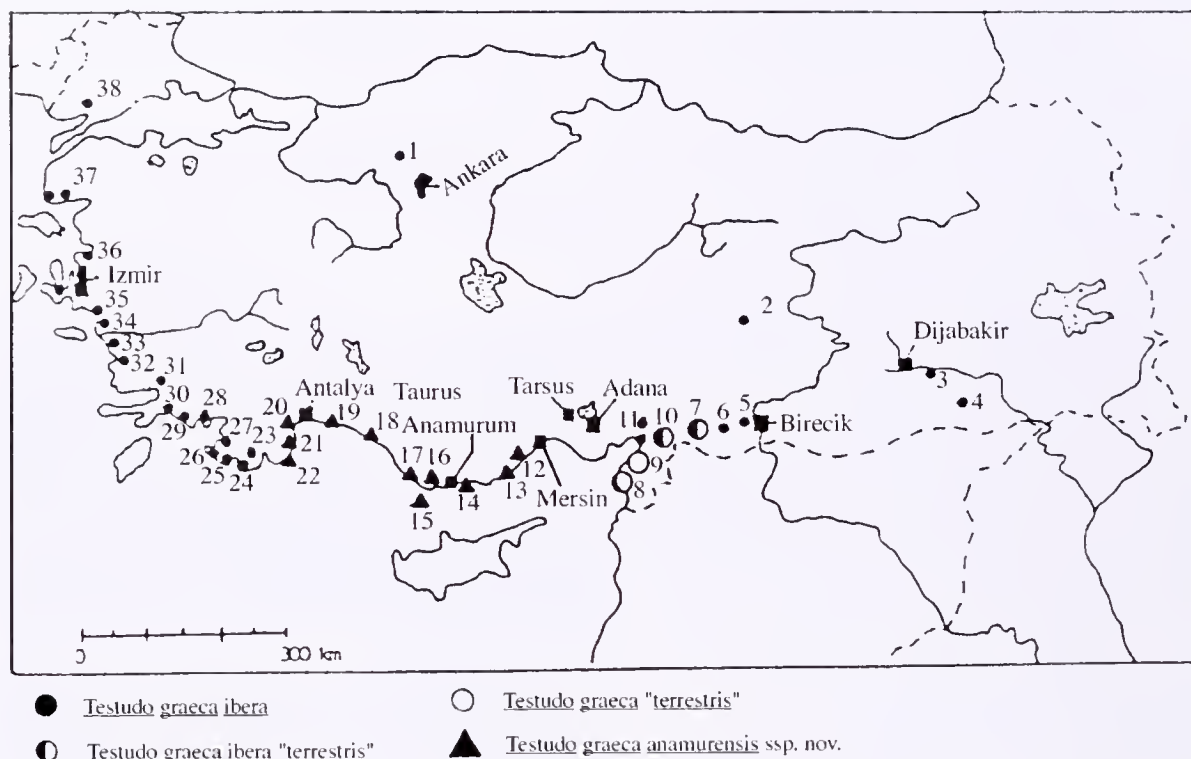


Figure 5. Localities of *Testudo graeca* in Turkey with dates that tortoises were observed (Weissinger, 1986). 1, ca. 70 km NW of Ankara, 5/18; 2, Doganşehir, open oak forest, 5/20; 3, 4 km from Dişabakir, 5/22; 4, 40 km from Mardin; 5, Birecik, 5/24; 6, Nizip, in the direction of Gaziantep, dry wadi, about 45° steep loam walls with tortoise burrows, 5/24; 7, ca. 10 km N of Islaniye, 5/24; 8, 20 km S of Iskenderund, 5/25; 9, ca. 20 km N. of Iskenderund, 5/26; 10, ca. 25 km of Fg, cornfield, 5/26; 11, 1 km from road crossing Ceyhan - Gaziantep, lava field, 5/26; 12, Ayas, 5/27; 13, Korykos-Kizkale, in the direction of Silifke, 5/27; 14, Bozyazi, onion field, 5/28; 15, Anamurum, 7 km W of Anamur, 5/29; 16, ca. 20 km W of Anamur, 5/29; 17 Pine forest, ca. 40 km W of Anamur, towards Gazipasa, 5/29; 18, Side, sand dunes, ruin-meadows, 5/30; 19, 20 km from Antalya, 5/31; 20, 10 km from Antalya, towards Kugla, 5/31; 21, Kemer, 5/31; 22, 10 km from Kemer, 5/31; 23, Mountain pass, ca. 800 m above sea level, towards Kas, 5/31; 24, Vavi, ca. 800 m above sea level, towards Kas, 5/31; 25, Kinis, wheat field, 6/1; 26, Letoon, tilled field, 6/1; 27, Esen, pine forest, 6/1; 28, Kargi, 6/1; 29, Köygeçiz, riverine forest with wet meadows 6/2; 30, Ula, 6/2; 31, Gökovalskele, 6/2; 32, Yatagan, 6/2; 33, Söke, towards Kusadasi, 6/2; 34, Selcuk, 6/3; 35, Pamucak, 6/4; 36, 2 km from Ayvacik, 6/6; 37, 15 km from Ayvacik, 6/6; 38, 20 km from Kesan, towards Greece (European Turkey).

Etymology

I name this South-west coast race after its terra typica, Anamurum, *Testudo graeca anamurensis*.

Distribution

The area of distribution of this race extends along the Southwest coast of Turkey from the Bey Dagları in the West to the plain of Mersin in the East. Most were found in the area between Side and Anamurum.

Acknowledgments

This translation was provided by Peter Paul van Dijk with some additions by Heinz Grillitsch. The translation was done with the permission and full agreement of the Austrian Herpetological Society. Figures 1-4 were provided by Jim Buskirk who, in turn, received

Weissinger's original slides from his widow. The editors of AHR would like to thank Heinz Grillitsch for his assistance in publishing this translation.

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Figure 6. The type specimen of *Testudo graeca anamurensis* Weissinger 1987, NMW 30795:1.

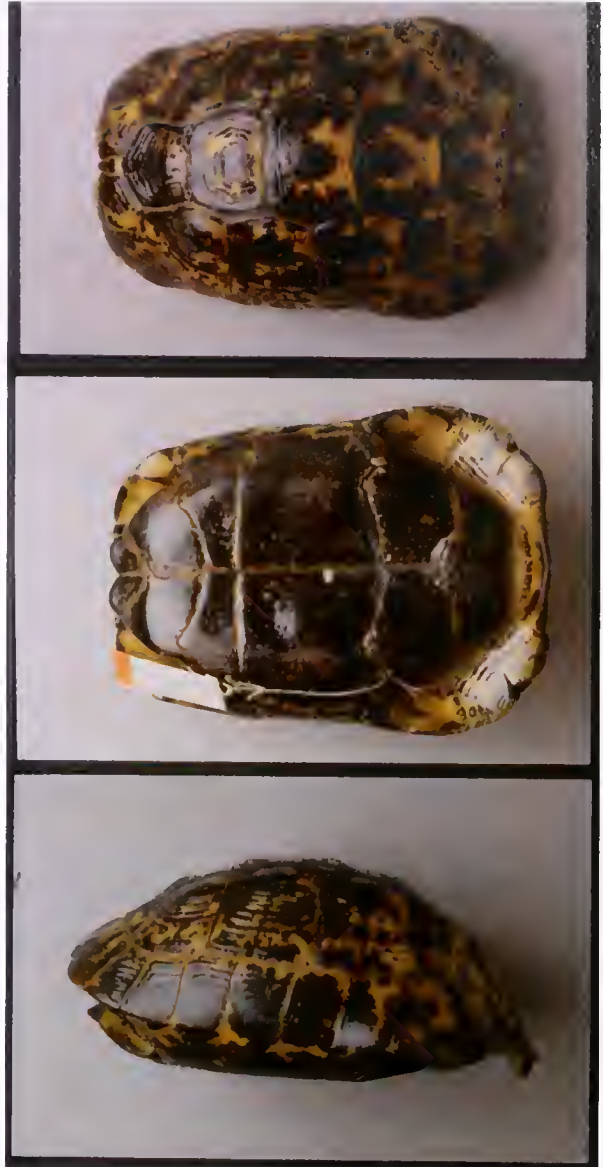


Figure 7. A male paratype of *Testudo graeca anamurensis* Weissinger 1987, NMW 30795:2.

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Appendix

This translation was prepared by Peter Paul van Dijk with some additions by Heinz Grillitsch of the Naturhistorische Museum Wien (NMW). This translation is published with the full permission of the Austrian Herpetological Society. In addition to the original figures, Heinz Grillitsch and Alice Schumacher (NMW) have provided additional figures of the original type series (Figs. 6-8). Uwe Fritz (pers. comm.), states that there are three additional paratypes in the collections of the Staatliches Museum für Tierkunde Dresden (MTKD 29200-29202). Finally, the female paratype that Weissinger lists as NMW 30795 is currently catalogued as NMW 31031 (Fritz and Grillitsch, pers. comm.).



Figure 8. A female paratype of *Testudo graeca anamurensis* Weissinger 1987, NMW 31031 (formerly 30795:3).

Book Review: A Guide to the Fauna of Iran

A Guide to the Fauna of Iran. Eskandar Firouz. Iran University Press; Tehran. 2000. vi + 491 pp

The first attempt to provide a comprehensive vertebrate zoology of Iran was that of William T. Blanford in 1876. Since that time, there have been treatises on various groups of vertebrates (e. g., mammals: Lay, 1967; Harrington, 1977; Ziaie, 1996; birds: Scott, et al., 1975; reptiles: Latifi, 1984 (snakes); Anderson, 1979 (turtles, crocodiles, and amphisbaenians), 1999 (lizards); amphibians: Baloutch and Kami, 1995; fishes: Coad, 1987, 1995. **A Guide to the Fauna of Iran** by Firouz is the first attempt since Blanford to bring all of the vertebrates of Iran together into a natural history guide.

Although the text is in Farsi (Persian), it is accessible to Western readers as a comprehensive list of the vertebrate species of Iran, since there is a Latin and English index, color illustrations with Latin species names, and lists of taxa with both Latin species names and English colloquial names. Most genera are represented by color illustrations, fishes by paintings, amphibians and reptiles by photographs, birds by paintings, and mammals by both. A list of the principal works consulted is provided (pp. 423-432). This list constitutes a good beginning bibliography for anyone interested in the vertebrate zoology and natural history of Iran.

For this book, the author has consulted the zoologists currently working on each of the vertebrate groups to assure that the species lists are up to date. The work covers 164 vertebrate families and 1054 species. Emphasis is given to conservation topics, including threatened and endangered species, problems of exotic introductions, and the ecological consequences of environmental change. The natural history sections include consideration of the zoogeography of Iran.

A renewed interest in zoology has occurred recently in Iran, the many universities including departments of biology and zoology are attempting to build knowledgeable faculties in these disciplines. This emphasis is largely due to the efforts of the author, Eskandar Firouz. Prior to the Islamic Revolution, Firouz was the principal architect of the conservation, natural history legislation and implementation in Iran through the Department of Environment, the establishment of Protected Regions and National Parks, and the regulation of hunting and fishing. These efforts were well on the way to setting a world standard for conservation and the study of natural history at the time of the revolution. Interests in natural

history have survived the period of resistance to perceived "Westernization" in Iran, and young scholars and conservationists must now face the daunting challenge of rebuilding the edifice of conservation initiated by Firouz and his colleagues in the 1960s and early 70s. The present book is yet another major contribution to that effort, and there should be a well-used copy in every local Department of Environment office, university and department library and in the personal libraries of individual zoologists and ecologists in Iran. It will also be a useful reference in specialized libraries, natural history museums, and conservation institutions in the West and in the countries of the former Soviet Union.

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Book Review: Four Recent Handbooks for Turkey

Türkiye Amfibiliri. The Amphibians of Turkey by Necla Özeti and I. Yılmaz, 1994. Izmir, 219 pp., 40 col. photos in pls., 92 text-figs. (In Turkish with English summary).

Tükiye Omurglılari, Amfibiler edited by Ali Demirsoy, 1996. Meteksan; Ankara, vi + 69 pp., numerous maps and figs. (In Turkish).

Tükiye Omurglılari, Sürüngenler edited by Ali Demirsoy, 1996. Meteksan; Ankara, viii + 205 pp., numerous maps and figs. (In Turkish).

Turkish Herpetofauna (Amphibians and Reptiles) by Ibrahim Baran and Mehmet Atatür, 1998. Republic of Turkey Ministry of Environment; Ankara, x + 214 pp., 122 col. pls., 7 text-figs. (In English).

Until the publication of these books, the standard herpetological summary publications for Turkey had been Başoğlu and Özeti (1973) and Başoğlu and Baran (1977, 1980). The four handbooks reviewed here accompanied us on a recent herpetological expedition to western and southern Turkey. The combination of these references enabled us to quickly identify most species in the field.

Turkish Herpetofauna by Baran and Atatür has a color photograph of each species, illustrated keys, one paragraph each on identification, habitat, biology, and distribution. The distribution sections include brief statements of the overall distribution and the range within Turkey. Where subspecies are recognized, a short distribution statement is given for each. There is no descriptive differentiation of subspecies. There are no distribution maps. The color photographs are of good quality and usually enabled quick identification of live specimens. Photos and text are on glossy paper and this hardback book is sturdily bound. The bibliography includes 53 references, and while not exhaustive, serves as a good introduction to the herpetological literature of Turkey. The nomenclature is reasonably current, with the exception, of course, of changes (e.g. the break-up of *Eumeces* and *Coluber*) since its publication. It is the only one of these handbooks to include *Rana dalmatina* Schneider, Sinch, and Nevo, 1992. Of the four, this book got most use on the trip, particularly as it is in English.

The two paper-bound books edited by Demirsoy, **Tükiye Omurglılari, Amfibiler** and **Tükiye Omurglılari, Sürüngenler** are useful to Western herpetologists, in particular, because they have a distribution map for each species, usually accompanied by a black and white illustration, often a photograph, but sometimes one or more line drawings. Although the books

are printed on high quality stock, many of the photographs have not reproduced well.

The tabular format of species presentation is somewhat unusual and innovative. These tables are the same for each species and include Latin and Turkish names, the author, date; one or more illustrations; distribution map for Turkey, showing both range and spot localities; remarks on habitats, relationships, taxonomic status, etc.; conservation status (rare, endangered, vulnerable, widespread, etc.); overall distribution and range within Turkey; type locality; greatest size; morphological characteristics; color pattern; reproduction; time from hatching to maturity; conservation status of habitats; defense mechanisms; population densities; potential hazards; zoogeographic origins; and conservation proposals for the future. A table listing the fauna summarizes the global and Turkish distributions, zoogeographic source, presumed geological time of arrival in Turkey, biogeographic and conservation status, and special remarks.

The books also contain descriptions and comments on higher taxa for the general reader. The bibliographies are extensive, much more so than that of the Baran and Atatür handbook in English. Contributors to these volumes are prominent Turkish herpetologists: Varol Tok, Ibrahim Baran, Mehmet Atatür, Abidin Budak, and Mehmet Öz. These volumes are obviously designed for the serious Turkish zoology student or wildlife professional and should serve this purpose well. They appear to be part of a larger series covering the entire Turkish fauna. Subspecies are covered individually, although there are some strange inconsistencies: sometimes there is a separate table and map for the species as a whole, in addition to the subspecies accounts, and sometimes not. The usage of generic names is sometimes confusing, as for example: *Cyrtodactylus* (= *Cyrtopodion*) (*Mediodactylus*) *heterocercus* and *Agama* (= *Laudakia*) *stellio* so that it not clear which generic name is recognized by the authors. As I don't read Turkish, I can't comment on errors in the text. Some of the range maps may be too general, especially in those cases where spot distributions are not shown. For example, *Laudakia stellio* is shown to extend to broad contact with the Iranian border, whereas it has never been recorded for Iran. We used the maps of these volumes in conjunction with the photographs and English text of the Baran and Atatür book and this greatly facilitated our work.

Türkiye Amfibiliri. The Amphibians of Turkey by Özeti and Yılmaz is aimed primarily at Turkish zoology students and serves as an introduction to amphib-

iology. It is an update, or second edition of Başoğlu and Özeti (1973). The first chapter is an introduction to nomenclature, and in particular, to the taxonomy of the Turkish amphibian fauna. One chapter deals with the biology of amphibians in general, including morphology, reproduction, development, distribution, and folklore. Two subsequent chapters cover these topics in more detail, one for salamanders and one for frogs. These chapters are arranged by family and include families not found in Turkey. They include keys to the Turkish genera and species and spot locality maps. These maps are useful, if somewhat cluttered (several taxa per map); localities are numbered and named in the figure legends. Keys to the generic level for egg masses and larvae have been provided. The descriptions and discussions of morphology are accompanied by useful illustrations taken from several sources (not always attributed). There is a short chapter on methods and techniques, a glossary, and a bibliography of 181 references, including the most important technical papers for the fauna, an excellent introduction to the literature of the Turkish amphibian fauna. At the end of the book are 13 plates of black and white photographs illustrating the covered taxa and some habitats. The photographs (or at least the printing of them) are of rather poor quality, although they are adequate to illustrate pattern differences between the species. An English summary includes a comprehensive key to the amphibians of Turkey. This key, along with the English figure legends, and specific collecting localities, makes this book particularly useful to non-Turkish speaking herpetologists.

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Book Review: Wild About Reptiles. Field Guide to the Reptiles and Amphibians of the UAE

Wild About Reptiles. Field Guide to the Reptiles and Amphibians of the UAE, by Marycke Jongbloed, 2000. Barkers Trident Communications; London, 116 pp., numerous unnumbered color photographs. Order from Natural History Book Service: www.nhbs.com

This attractive little spiral-bound book is the first field guide to the amphibians and reptiles of the United Arab Emirates. Most of the 68 species covered are illustrated with good color photographs. There are no keys, but the color photographs will serve to identify most live specimens. Descriptions are sketchy and the emphasis is on natural history. The book should serve well as an introduction to desert reptiles, sea snakes and sea turtles, and the few amphibians of the region. English speakers who work in the Emirates, particularly members of the natural history societies, will find this a handy reference. Visiting herpetologists, while they will still want the keys and descriptions of Arnold (1986), Balletto, *et al.* (1986), Gasperetti (1988), Leviton and Anderson (1967), and Leviton, *et al.* (1992), will want this for quick identification. The technical papers that emphasize the herpetology of the Emirates are few in number (see Arnold, 1984; Leviton and Anderson,) and only Arnold (1984) concerns the ecology and natural history of this region of the Arabian Peninsula.

Jongbloed takes a highly personal and anecdotal approach in this book, demonstrating her enthusiasm for these creatures. She includes field notes taken by her friend, John Norman Bishop "Bish" Brown. Because so little professional herpetological work has been done in the Emirates, and those studies that have been carried out have dealt mainly with systematics, using preserved specimens, this book is almost the only source of natural history information for these groups in the UAE. The natural history observations are informal, but still, informative. The bibliography is sketchy and disappointing and will not lead the beginning naturalist very deeply into the literature of the UAE.

I recommend this field guide to any naturalist, professional or amateur, planning to travel to the UAE.

Anyone seriously interested in the herpetofauna of Southwest Asia in general or the Arabian Peninsula in particular will want this in his library.

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Obituary: Sherman Anthony Minton Jr.

MUHAMMAD S. KHAN

7740 NW, 47th Street, Lauderhill, FL 33351, USA

Dr. Sherman Anthony Minton Jr., died of cancer in Indianapolis, Indiana, USA, on 15 June 1999, at the age of 80. He was born on the 24 February 1919, in New Albany, Indiana, where he also attended school. He had a fondness for amphibians and reptiles even in his childhood. He was the eldest child of Senator Sherman Minton Sr., on whose suggestion young Sherman chose medicine instead of law, since medicine was closer to zoology. He obtained a BS in Zoology in 1939 and an MD in 1942 at Indiana University. He served during World War II in the U.S. Navy from 1943-1946. After the war, Sherman spent 1947-1948 at the University of Michigan Zoology Department, taking Herpetology and Microbiology. He later joined the faculty of Indiana University School of Medicine, in the Department of Microbiology and Immunology, where he remained until he retired as Emeritus Professor in 1984. Dr. Minton's career presents a beautiful amalgamation of medicine, microbiology, and herpetology.

Sherman married Madge Alice Shortridge Rutherford on 10 October 1943, while both were in military service. He was in the Navy and she was flying with the Women Air Force Service Pilots (WASP). Interestingly, Madge has also been interested in snakes from her childhood, so their relationship was also professional. They co-authored eight publications including two books, *Venomous Reptiles* (Minton and Minton 1969, 1980) and *Giant Reptiles* (Minton and Minton, 1973).

Minton took a break from Indiana (1958-1962) to teach at the Basic Medical Sciences Institute, Karachi, Pakistan (now Postgraduate Medical Center), as part of the U.S. AID program. He taught at the institute, reorganized the medical teaching courses, and headed the institute for a short time.

He pioneered herpetological studies in Pakistan. Both he and his wife Madge Minton traveled 44,000 miles in different parts of Pakistan, collecting amphibians and reptiles and information about them from the local people. One of the results of this is the well-illustrated paper on the amphibians and reptiles of Sind and Las Bela (1962). In 1965, he visited Iran and Pakistan under the sponsorship of American Museum of Natural History and collected material for his main book on the herpetology of Pakistan (1966).



Sherman, with Madge's constant support and help, produced over 170 articles, books and monographs. He was a pioneer in the study of venomous reptiles and toxicology. He was on the editorial board of the journals *Toxicon* and *Clinical Toxicology*. He was the chairman and a member of the major professional societies in his field and received numerous awards and honors for his work. He also made a significant contribution to the herpetology of Indiana.

From 1972-1980 he joined several expeditions to different oceans to study biology of sea snakes and other venomous sea animals. He was visiting professor in the Department of Zoology, University of New England in Australia during 1980.

In remembrance of Dr. Minton's services to the herpetology of Pakistan, the following fossil Ameri-

can frog and Pakistani lizard and snakes have been named after him:

Proacris mintoni Holman, 1961

Coluber karelini mintonorum Mertens, 1969

Gymnodactylus mintoni Golubev and Szczerbak, 1981

Typhlops madgemintonai shermanai Khan, 1999

Dr. Sherman A. Minton, Jr., is survived by his widow Madge Rutherford Minton, and three daughters.

Literature Cited

Golubev, M., and Szczerbak, N. N. 1981. A new species of *Gymnodactylus* Spix, 1923 (Reptilia, Sauria, Gekkonidae) from Pakistan. *Vestnik Zoolii* 1981:40-45, (in Russian).

Holman, A. 1961. A fossil frog from the Lower Miocene of Florida. *Copeia* 1961(3):354-355.

Khan, M. S. 1999. Two new species and a subspecies of blind snakes of genus *Typhlops* from Azad Kashmir and Punjab, Pakistan. *Russian Journal of Herpetology* 6(3): 231-240.

Mertens, R. 1969. Die Amphibien und Reptilien West-Pakistans. *Stüttgarter Beiträge zur Naturkunde* 197: 1-96.

Minton, Jr., S. A. 1962. An annotated key to the amphibians and reptiles of Sind and Las Bela, West Pakistan. *American Museum Novitates* 2081: 1-21.

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Minton Jr., S. A., and Minton, M. R. 1969. *Venomous Reptiles*. Charles Scribner's Sons, New York. 274 pp.

Minton Jr., S. A., and Minton, M. R. 1973. *Giant Reptiles*. Charles Scribner's Sons, New York. 345 pp.

Minton Jr., S. A., and Minton, M. R. 1980. *Venomous Reptiles*. Charles Scribner's Sons, New York. 308 pp.

Stewart, M. M. 2000. Madge and Sherman Minton. *Copeia*, 2000(1): 304-309.

Guidelines for Manuscript Preparation and Submission

NOTE: AHR now requires all tables to be submitted camera-ready. Please send hard copy, or electronic images of tables in the following format:

Table 1. AHR Standard table format. Note double line under heading row. Please use a sanserif font (Helvetica 10pt or Ariel 10pt).

Column 1	Column 2	Column 3	Column 4
12.4	43321.5	9.1	0.01
12.1	91020.4	0.6	0.02

Summary

Manuscripts must:

- 1) be written in English.
- 2) be of letter quality (laser printed or typewritten on bond paper).
- 3) include camera ready tables and figures (if any).
- 4) include complete and accurate literature citations.
- 5) include complete and accurate localities with latitude and longitude.
- 6) include a camera ready map illustrating regions discussed (when applicable).

Tips for electronic submission

- Do not type authors names in all capitals in literature cited.
- Do not use two spaces following a period, or for any other purpose.
- Do not attempt to recreate the format of the journal in your manuscript. Please use only simple formatting limited to italics, boldface, and underline.

Manuscripts failing to meet these criteria will be returned without review for correction.

Purpose and Content

Asiatic Herpetological Research publishes articles concerning but not limited to Asian herpetology. The editors encourage publications from all countries in an attempt to create an open forum for the discussion of Asian herpetological research.

Articles should be in standard scientific format and style. The following sections should be included:

Title

The title should reflect the general content of the article in as few words as possible. The editors encourage titles that summarize the main findings of the article.

Names and Addresses

The names and addresses of all authors must be complete enough to allow postal correspondence. Please include email and World Wide Web addresses if applicable.

Abstract

The abstract should briefly summarize the nature of the research, its results, and the main conclusions. Abstracts should be less than 300 words.

Key Words

Key words provide an index for the filing of articles. Key words provide the following information (when applicable): 1) Taxonomy (e.g. Reptilia, Squamata, Gekkonidae, *Gekko gecko*). 2) Geography (e.g. China, Thailand). 3) Subject (e.g. taxonomic validity, ecology, biogeography). The order of taxonomy, geography, and subject should be observed.

Text

Manuscripts must be in English and spelling must be correct and consistent. Use *Webster's New International Dictionary* for reference. For clarity, use active voice whenever possible. For example, the following sentences in active voice are preferable to those in passive voice.

Active voice: "Lizards were extremely common on the site." and "I examined three female snakes."

Passive voice: "Lizards were observed to be extremely common on the site." and "Three female snakes were examined."

Abbreviation

Do not abbreviate unless the full phrase has already appeared. Scientific names may be abbreviated only if they have appeared fully in the same paragraph. Never begin a sentence with an abbreviation of a scientific name.

Statistics

Statistics must be accompanied by sample sizes, significance levels, and the names of any tests. Investigators should pay careful attention to independence and applicability of tests, and randomness of samples. One of the most frequent examples of nonindependence is the use of multiple, paired t-tests instead of analysis of variance (anova). In general, multiple tests on the same data set are not valid. Descriptive statistics are in many cases more appropriate than inferential statistics.

Standard Format

Manuscripts following standard format should include introduction, methods, results, and discussion sections. While other formats are acceptable, the editors encourage the use of standard format. **Please do not type in all capital letters.**

Introduction

The introduction typically states the significance of the topic and reviews prior research.

Material and Methods

This section should clearly state where, when, and how research was carried out. Include sample sizes. Protocols designed by other investigators must be properly cited. Research materials and their manufacturers should be listed. The reader must be able to replicate the methods of the author(s).

Results

This section states the results and their significance to the investigation. Figures and tables may be used to clarify, but not to replace, results statements in the text. Statistics should be used when applicable. Large amounts of data should be avoided, or included as an appendix at the end of the article.

Discussion

The discussion is a synthesis of the introduction and the results. No new information should be discussed unless it was presented in the results section. New findings should be discussed in relation to prior research. The author(s) should feel free to present several possible interpretations of the results. The editors particularly encourage suggestions of future research in Asian herpetology.

Manuscript Preparation

Overview

Please do not attempt to replicate the formatting style of AHR in your manuscript. All formatting except italics will be removed in the production process. Bold and underlined text should be used only to identify section heading levels (see below). Extraneous formatting is counterproductive and increases the production costs of the journal. There are a few simple guidelines that authors must follow.

Section Headings

Articles will be published using three section heading styles. All heading levels must be on their own line, and left justified. For the purposes of manuscript submission, Level 1 heading is **bold**, and generally reserved for Introduction, Material and Methods, Results, and Discussion; Level 2 is *italic*, and Level 3 is underlined.

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Figures **must** be referenced in order in the text. Each figure illustration (line art or photograph) submitted must be "camera ready" for publication with no modifications necessary other than reduction. AHR does not publish "plates"; please refer to these as figures numbered sequentially. Do not write on figure; do not mount more than one figure to a sheet. AHR cannot be responsible for redrawing, touching up, or otherwise modifying figure illustrations for authors. In addition, figure illustrations submitted must:

- 1) be of publication quality with typeset text.
- 2) be mounted on a separate 21.5 x 28 cm (8.5 x 11 inch) sheet with figure number on back.
- 3) be on a separate sheet from figure legend.
- 4) not have poor type or handwriting on the face of the figure.
- 5) The TIFF file format is preferable for electronic versions of figures, but Photoshop, JPEG, or PICT formats are acceptable. Resolution of electronic versions of figures must be at least 600 dpi for line art, or 300 dpi for grayscale and color images.
- 6) Figures will be reduced to either 1 column (3.25") or two columns (6.5").

Times Roman typeface is preferred. In order to avoid wasted effort, please follow the above instructions carefully. Please note: AHR will not alter or lay out figures for publication. Any figure requiring modification will be returned, and may cause significant delay in publication.

Figure Legends. Figure legends should be typed on a separate sheet. Legends should explain the figure without reference to the text. A figure and legend should make sense if separated from the rest of the article. For example:

Figure 2. Lateral view of live *Psammodynastes pulverulentus* holding a prey lizard (*Anolis carolinensis*). Note buccal tissue surrounding the enlarged anterior maxillary and dentary teeth of the snake.

Color Figures. AHR may publish color figures at the discretion of the editors. AHR is now published both on paper and electronically. Printing costs of color figures may be required for the paper version of AHR. Color figures will be published free of charge in the electronic version. If you submit color figures, please indicate if you wish them to be considered for publication in color in the paper version. Otherwise, they will be converted to black and white in the paper version.

Tables

Tables **must** be referenced in order in the text. AHR now requires that all tables be submitted camera-ready in AHR's standard format. See Table 1 (above) and prior copies of AHR for examples. Please use a sanserif font (Helvetica 10pt or Ariel 10pt).

Typeface

Twelve point type is preferred. Supply a detailed list of special characters (greek letters, male or female symbols, etc.) that are not part of a standard font.

Literature Cited

Accurate and standard references are a crucial part of any article. This is especially important when dealing with publications from many different countries. The reader must be able to precisely identify any literature cited. References in the text must be checked for consistency with references in the literature cited section. All references cited in the text must be in the literature cited section. The literature cited section may not contain any references not mentioned in the text. Articles containing inaccurate or inconsistent literature citations will be returned for correction.

References in Text. 1) References to articles by one or two authors must include both surnames in the order they appear in the original publication. References to articles by more than two authors must include the first author's surname, followed by "et al." 2) The year of article follows the authors, separated only by a space. 3) References with the same author and year are distinguished by the lower case characters "a, b, c, . . ." 4) References cited in text are listed in alphabetical order by first author.

For example, "My results also incorporate literature records (Marx et al., 1982; Marx and Rabb, 1972; Mertens, 1930; Pope, 1929; Wall, 1909, 1910a, 1910b, 1910c)."

References in Literature Cited. 1) References must include all authors, in the order that they appear in the original publication; "et al." is never used in a literature cited section. 2) The first author is listed surname first, initial(s) last. All other authors are listed initial(s) first, surname last. 3) References with the same author and year are distinguished by the lower case characters, "a, b, c, . . ." 4) References cited are listed in alphabetical order by first author. 5) Names of journals are not abbreviated. See below for examples:

Journal article

Dial, B. E. 1987. Energetics and performance during nest emergence and the hatchling frenzy in loggerhead sea turtles (*Caretta caretta*). *Herpetologica* 43(3):307-315.

Journal article from a journal that uses year instead of volume

Gatten, R. E. Jr. 1974. Effect of nutritional state on the preferred body temperatures of turtles. *Copeia* 1974(4):912-917.

Journal article, title translated, article not in English

Ananjeva, N. B. 1986. [On the validity of *Megalochilus mystaceus* (Pallas, 1776)]. *Proceedings of the Zoological Institute, Leningrad* 157:4-13. (In Russian).

Note that for *Acta Herpetologica Sinica*, the year must precede the volume number. This is to distinguish between the old and new series, and between 1982-1987, Vols.1-6 (new series) and 1988 with no volume number, numbers 1 and 2 (new series).

Cai, M., J. Zhang, and D. Lin. 1985. [Preliminary observation on the embryonic development of *Hynobius chinensis* Guenther]. *Acta Herpetologica Sinica* 1985, 4(2):177-180. (In Chinese).

Book

Pratt, A. E. 1892. *To the snows of Tibet through China*. Longmans, Green, and Co., London. 268 pp.

Article in book

Huey, R. B. 1982. Temperature, physiology, and the ecology of reptiles. Pp. 25-91. In C. Gans and F. H. Pough (eds.), *Biology of the Reptilia*, Vol. 12, *Physiological Ecology*. Academic Press, New York.

Government publication

United States Environmental Data Service. 1968. *Climatic Atlas of the United States*. Environmental Data Service, Washington, D. C.

Abstract of oral presentation

Arnold, S. J. 1982. Are scale counts used in snake systematics heritable? SSAR/HL Annual Meeting. Raleigh, North Carolina. [Abstr].

Thesis or dissertation

Moody, S. 1980. Phylogenetic and historical biogeographical relationships of the genera in the Agamidae (Reptilia: Lacertilia). Ph.D. Thesis. University of Michigan. 373 pp.

Anonymous, undated

Anonymous. Undated. Turpan brochure. Promotion Department of the National Tourism Administration of the People's Republic of China, China Travel and Tourism Press, Turpan, Xinjiang Uygur Autonomous Region, China.

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Manuscripts will be reviewed. The editors will attempt to choose reviewers whose research knowledge most closely matches the content of the manuscript.

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